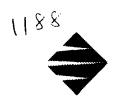
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SFUND RECORDS CTR 2092368

MEMORANDUM

SUBMITTED TO:	Rachel Loften, U.S. Environmental Protection Agency		
PREPARED BY:	Timothy Swillinger, ICF Technology, Incorporated		
тнкоисн:	Matthew Williams, Ecology and Environment, Incorporated		
DATE:	July 25, 1991		
SUBJECT:	Completed Work		
COPY:	Marcia Brooks, Ecology and Environment, Incorporated		
This list is for the atta	ched completed:		
PA X P	A Review SSI LSI		
Other EPI-PA			
Site Name:	Zeta Laboratories, Inc.		
EPA ID#:	CAD049233570 (214)		
City, County:	Santa Clara, Santa Clara		
State Recommendation: (for Reviews only)			
	FOR EPA USE ONLY		
CERCLIS Lead: EPA PA-1 Complete 5" C399 (E)			

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ICF TECHNOLOGY INCORPORATED

ENVIRONMENTAL PRIORITIES INITIATIVE PRELIMINARY ASSESSMENT

Purpose: RCRA Preliminary Assessment

Site: Zeta Laboratories, Inc.

3265 Scott Blvd.

Santa Clara, California Santa Clara County

Site EPA ID Number: CAD049233570

TDD Number: F9-9102-058

Program Account Number: FCA1718RAA

FIT Investigators: Timothy Swillinger, ICF Technology, Incorporated

Report Prepared By: Timothy Swillinger, ICF Technology, Incorporated

Report Date: July 25, 1991

FIT Review/Concurrence: fames M. fame 7/30/91

Submitted To:

Rachel Loftin

Site Assessment Manager, EPA Region IX

1. INTRODUCTION

As part of the its Environmental Priorities Initiative (EPI) program, the U.S. Environmental Protection Agency (EPA) has requested ICF Technology, Inc.'s Field Investigation Team (FIT), subcontractors to Ecology and Environment, Inc., to conduct a Preliminary Assessment (PA) of Zeta Laboratories located at 3265 Scott Blvd., Santa Clara, California.

The EPI program integrates the Resource Conservation and Recovery Act of 1976 (RCRA), as amended by the 1984 Hazardous and Solid Waste Amendments (HSWA) with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980

(CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), in order to set priorities for cleanup of the most environmentally significant sites first. The PA is conducted using CERCLA Hazard Ranking System (HRS) criteria to determine the site's eligibility for inclusion on the National Priorities List and, thus, assist in prioritizing facilities for the RCRA Program.

2. SITE DESCRIPTION

2.1 Site Location and Owner/Operator History

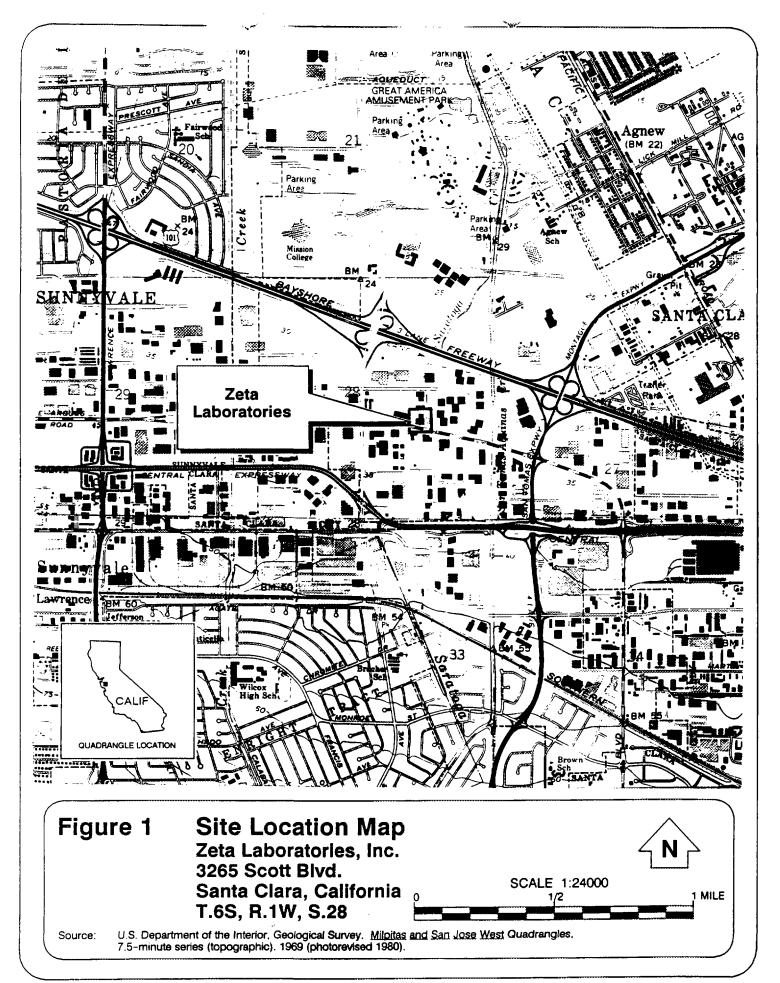
The Zeta Laboratories site (Zeta) is located at 3265 Scott Blvd., in Santa Clara, California (T. 6S., R. 1W., sec. 27, Mount Diablo baseline and meridian; lat. 37° 20' 42", long. 121° 56' 48") (1,2). A site location map is presented as Figure 1. The property is currently owned by Rosenberg Real Estate Equity Fund II, Inc., of Sunnyvale and is situated in a primarily high technology industrial area in the city of Santa Clara (2,48). Prior to 1976, the property was used for agriculture, most likely for the cultivation of citrus fruits (66). In 1977 Zeta first occupied one of three buildings that were known as the San Thomas Business Park, which was owned by the San Thomas Development Company. During the time that Zeta occupied the site, the property was sold to the Rreef Fund of Palo Alto (51). Zeta vacated 3265 Scott Boulevard in Santa Clara in 1987, and moved operations to 2811 Orchard Parkway in San Jose (51).

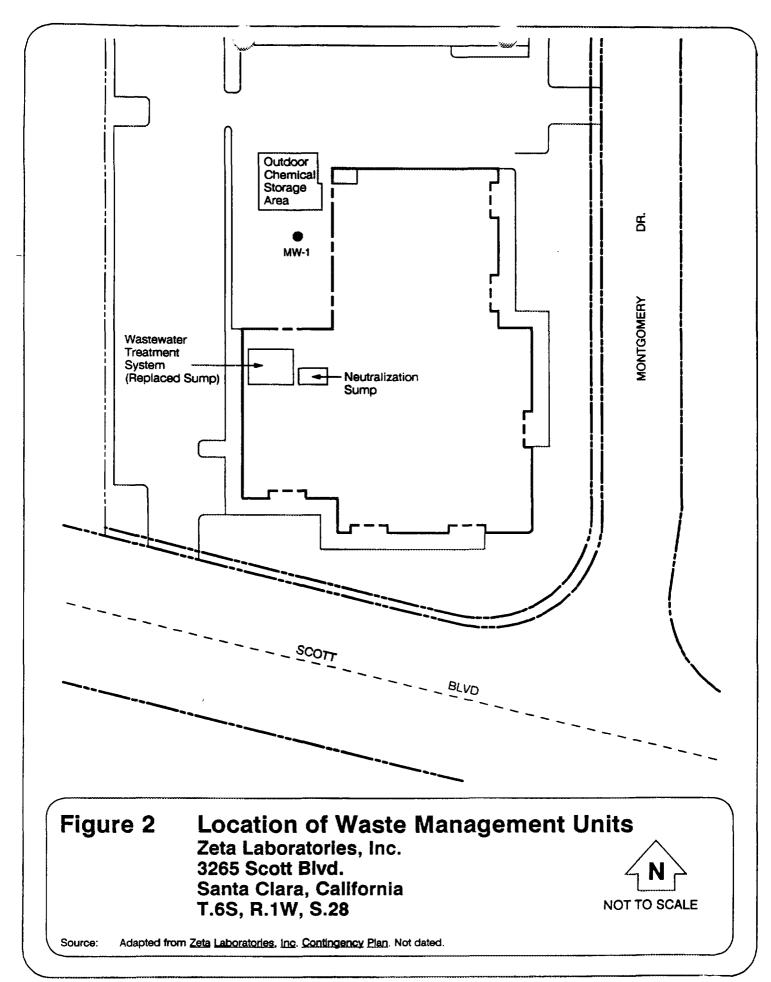
Zeta operated at 3265 Scott Boulevard as a microwave communication component and printed circuit board manufacturer from 1977 to 1987. Zeta was owned by Computer & Communications Technology (CCT) of San Diego, which held the lease at 3265 Scott Boulevard. The site covers approximately 30,000 square feet, and is bordered to the north by an office building (part of the business park), to the south by Scott Boulevard, to the east by Montgomery Street, and to the west by a parking lot (2,45,47,51). Past on-site facilities consisted of one building and a former paved and fenced chemical storage area (49). Within the facility, Zeta operated a paint booth (67). A facility map which shows past waste management units is presented as Figure 2. The building is still present at the site and is currently subdivided into three businesses: Ultracision, Cabokit, and Sonictron, none of which reportedly use hazardous materials or generate hazardous waste (2,30,32). The former chemical storage area has been removed and repaved and is now a parking lot (2). None of the current tenants at the site are listed on the CERCLIS or RCRA Databases (3,4). The site is mostly paved, with some areas landscaped with grass and trees (2).

2.0 Facility Process/Waste Management

2.2.1 Historical

Zeta began operations at 3265 Scott Boulevard in Santa Clara in 1977, as a manufacturer of microwave communication components systems and printed circuit boards (29,45). In





1981, Zeta submitted a Part A application with EPA for storage in containers (69). Zeta occupied this site until 1987 (51). Manufacturing processes involved electroless copper deposition, copper and tin lead plating, scrubbing and stripping, copper etching, gold plating, alodine process, solder fusing, zincate copper plating, developing, and dry film stripping (44).

Two types of chemical wastes were generated at Zeta: 1) spent chemical baths and paint wastes such as thinners, which were hauled off-site for disposal, and 2) rinse waters containing dilute amounts of chemicals, which were pretreated before discharge to the sanitary sewer. The rinsewaters contained corrosive chemicals and metals (49).

Zeta's chemical wastestreams included residual acid, ferric chloride, copper, chromium, chromic acid, fluoride, water, cyanide, trichloroethane (TCA), calcium oxide, sodium hydroxide, lead, nitrite, aliphatic hydrocarbons, acetone, methanol, acetates, toluene, 1nitropropane, and corrosive lab-packs (12). The spent chemical baths and rinses were periodically replaced. The spent baths and rinses were pumped into 55-gallon polyethylene drums. Paint wastes and thinners were transferred to metal 55-gallon drums as they were generated. Reportedly, drums were kept in a bermed and fenced outdoor chemical storage area for less than 90 days (49). These drums were segregated by waste type using bermed sub-divsions of the storage area. Wastes were collected by waste haulers and transported to treatment, storage, and disposal facilities (49). Wastes were disposed of by Solvent Services, Inc. (EPA ID# CAD059494310), Ultra-Chem (EPA ID# CAT080013535), South Bay Chemical (EPA ID# CAD000628147) and Chemical Waste Management Inc. (EPA ID# CAD003986718). The ultimate disposition of the wastes were the Class I disposal sites at Chemical Waste Management Kettleman Hills, (CAT000646117), and Casmalia Resources (EPA ID# CAD020748125). Waste thinners and paints may have been reclaimed by Solvent Service or Ultra-Chem (29,49).

Waste rinse water from the plating processes was generated when parts were rinsed after emersion in a chemical bath. The rinse water from this process was hard-plumbed to the treatment system consisting of a below-ground neutralization tank. In 1986, the tank was removed and replaced by a new treatment system. This new system allowed rinse waters from cyanide-containing tanks to be piped to a cyanide treatment tank before transfer to a metal precipitation tank. Similarly, rinse water from chromium bearing solutions went to a chromium reduction tank, before transfer to the metal precipitation tank. Monthly wastewater analysis was performed on the effluent of the treatment system for pH, cyanide, copper, chromium, lead, and zinc. On a weekly basis an in-house analysis was performed for pH, copper, chromium, and cyanide in order to monitor the efficiency of the treatment system (49). The treatment sludge from both systems was removed and stored in drums in the chemical storage area (49).

2.2.2 Current

The site has been subdivided and is currently occupied by Ultracision, Cabokit, and Sonictron. Cabokit and Sonictron both assemble electronic cable harnesses, and reportedly

do not handle any hazardous materials or hazardous waste (2,30,32). Ultracision assembles automation equipment (robotics), and also reportedly does not handle any hazardous materials or hazardous waste (2,31). The former Zeta drum containment area has been removed, repaved, and is now used as a parking lot (2,29). The neutralization system that replaced the sump was dismantled during closure activities in 1987 (51).

3. REGULATORY INVOLVEMENT

3.1 Environmental Protection Agency (EPA)

Zeta Laboratories has been registered on the RCRA database as a hazardous waste generator, and a treatment and storage facility, at 3265 Scott Boulevard since August 1980. Zeta filed for its Part A application in 1981 (69). A Part B was never filed, and closure activities were approved by DHS (29,42).

3.2 California Department of Health Services (DHS)

Zeta applied for a California Extremely Hazardous Waste Disposal Permit in July 1981, which was issued by DHS for one year (33). This permit was renewed the following year (34). Zeta was issued an Interim Status Document (ISD) from DHS on December 16, 1981 (35).

In April 1983, Zeta applied to DHS for a variance from the ISD requirements for their wastewater neutralization sump (36). In June 1983, Zeta was notified that they were eligible for the variance, pending a compliance inspection and application review (37). During the May 1984 DHS inspection, Zeta was found to be in compliance with all applicable generator requirements (38). In June 1984, Zeta was informed that in order to be considered for a variance, the existing neutralization sump would have to be modified to add a leak detection system or a new system would have to be installed. Zeta was instructed to resubmit the variance application once either of these options had been selected (39).

In September 1985, DHS denied the initial variance request pending review of construction plans for the proposed neutralization unit (40). In October 1986, the new neutralization unit was installed with secondary containment. Zeta established with DHS that resulting cyanide and chrome levels were below the agency's Extremely Hazardous levels and requested a variance and a withdrawal of the ISD. After further review of the request, DHS agreed to the withdrawal request because wastes were stored for less than 90 days, and only neutralization was done (29,42).

In June 1987, the facility closed, the neutralization system and the drum storage area were removed, and Zeta moved operations to the current location in San Jose (2,29). In November 1987, formal confirmation and approval of the closure procedure was stated by

DHS in writing (29,42). There were no reported violations pertaining to hazardous materials or hazardous waste issued by DHS, and no reported evidence of uncontained hazardous substances during seven years of regulatory oversight at Zeta Laboratories (8). Zeta Laboratories is not listed on the California Bond Expenditure Plan for hazardous waste sites (14).

3.3 San Jose/Santa Clara Water Pollution Control Plant

The San Jose/Santa Clara Water Pollution Control Plant issued an Industrial Wastewater Discharge Permit to Zeta (SC-038B, effective 1982) which expired in October 1985. The permit required Zeta to provide quarterly sampling reports for levels of copper, nickel, and lead and semi-annual sampling reports for levels of cadmium and cyanide in the treated rinsewater. The permit established Maximum Allowable Discharge limits for Zeta for the compounds as shown in Table 1 (44).

Table 1.

Maximum Allowable Discharge limits set forth by the San Jose/Santa Clara Water Pollution Control Plant for Zeta Laboratories, 1982.

Constituent	Maximum Allowable Discharge (mg/l)
Cadmium	0.7
Chromium	1.0
Copper	2.7
Lead	0.4
Nickel	2.6
Zinc	2.6
Cyanide	1.0
рН	5.0 - 10.5 (range)

According to Zeta, these limits were never exceeded (51). However, analytical results of wastewater samples show that Zeta exceeded discharge limits for copper and pH three times in 1985 (19,20,21)

3.4 Santa Clara Fire Department

The City of Santa Clara Fire Department (SCFD), Chemical Division required Zeta to file a hazardous substance inventory (7). In June 1987, Zeta notified the SCFD of its intent to close the facility and move to San Jose, and provided a closure plan (45). The SCFD

supervised the closure and inspected the facility to determine that the closure plan was completed (29,46). The SCFD has no record of violations issued to Zeta pertaining to hazardous materials or hazardous waste (7).

3.5 Other Agency Involvement

The Regional Water Quality Control Board (RWQCB) has no file information on Zeta Laboratories and is not currently involved with the site (6).

The Bay Air Quality Management District (BAAQMD) has no record on file of a permit for Zeta Laboratories and is not currently involved with the site (5).

The Santa Clara County Department of Environmental Health has no file information on Zeta and is not currently involved with the site (64).

4. DESCRIPTION OF INDIVIDUAL SOLID WASTE MANAGEMENT UNITS

Distinct Solid Waste Management Units (SWMUs) have been identified to evaluate potential on-site sources of releases to air, surface water, groundwater, and soil. A SWMU is defined as any discernible waste management unit at a facility from which hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid and/or hazardous waste. As a result of this Preliminary Assessment, FIT has identified three significant SWMUs at the site. It appears that none of these units are RCRA-regulated. Additional SWMUs may exist.

4.1 Drum Storage Area.

Unit Description

The drum storage area was located outdoors, adjacent to the building (see Figure 2), and was bermed and fenced. The area was designed to contain 30 drums and was segregated into corrosive, flammable, and toxic storage areas by additional bermed sub-divisions, however, according to Zeta, no more than 15 drums were usually stored at any time. Waste was stored no longer than 90 days (49).

Date of Start-up

The exact date of the start-up is not known, however, it is assumed that the area was put in use after the time of the establishment of the facility, which was in 1977 (51). Bermed subdivisions were installed in 1983 (36).

Date of Closure

The area was removed and repaved in June, 1987 (2,29).

Waste Managed

The area was used for the storage of drums of paint sludge and thinners, spent alkalies, spent acids, spent plating baths that contained metals, cyanide wastes, and treatment sludge (49).

Release Controls

Spill control was provided by a drainage collection sump. The combined berm and sump capacity was approximately 30 drums (49). In addition, the concrete floor of the storage area was coated with epoxy (51).

History of Releases

There is no documentation which indicates that there was a release from this storage area. There is no information to indicate that any sampling has been conducted in the area beneath the storage area. According to the facility manager, there were never any known releases from this unit (51). However, according to a report prepared by Zeta's environmental consultant, the area was flooded from rain at least twice (53).

4.2 Neutralization Sump

Unit Description

The neutralization sump was a 55-gallon below-ground tank which discharged directly to the sanitary sewer. The tank was made of polyethylene and was encased in concrete. Limestone was used in the sump to neutralize wastes prior to discharge (49).

Date of Start-up

The date of start-up was 1979 (66).

Date of Closure

The unit was removed on October 10, 1986 (29).

Waste Managed

The tank received rinse waters from plating baths described in section 4.1, which were neutralized by limestone rocks in the unit before discharge to the sanitary sewer (49,51).

Release Controls

The tank was encased in concrete. There are no other known release controls for the tank (49).

History of Releases

Soil sampling was performed when the tank was removed. The location of the sampling was directly beneath the point where the effluent stream entered the tank, approximately two feet below ground surface. No background samples were taken. Metals present in the waste stream were found in the soil, however none were found at levels above state action levels. According to the facility manager, there were no releases from this unit (43,51).

4.3 Waste Treatment System

Unit Description

The waste treatment system replaced the neutralization sump. It was composed of three tanks: a cyanide treatment tank, a chromium reduction tank, and a metal precipitation tank. The combined total tank volume was 890 gallons. The tanks were made of polypropylene and surrounded by a secondary containment tray that was made of polyvinyl chloride. Waste rinsewater was plumbed directly to the treatment system. The unit was located aboveground and indoors (49,51).

Date of Start-up

The waste treatment system was installed October 10, 1986 (29).

Date of Closure

The system was removed in June 1987 when the facility closed (29).

Waste Managed

The tanks received rinse waters from plating baths described in Section 4.1. Cyanide-containing rinse water went through a cyanide treatment tank before entering a metal precipitation tank. Chromium-bearing solutions were piped to a chromium reduction tank before entering the metal precipitation tank. Treated rinse water from the metal precipitation tank was discharged to the sanitary sewer (49,51). Treatment sludge was removed and stored in 55-gallon drums in the chemical storage area (49).

Release Controls

A large secondary containment tray was installed around the entire waste treatment system. This containment was designed to contain 110% of the total tank volume (49,51).

History of Releases

There is no documented release from this system. According to the facility manager, there were never any known releases from this unit (51). There was no known sampling beneath this unit.

4.4 Areas of Concern

FIT identified two areas of concern: the loading dock area where above-ground tanks were kept, and a area of freon-contaminated soil located near another building within the business park.

Aerial photographs taken in 1989 showed seven above-ground storage tanks located in the loading dock area of the Zeta site (66). According to the facility manager, Zeta did not have any outdoor storage tanks (51). Therefore, it is possible that these tanks were installed, used, and removed by another operator between 1987, when Zeta relocated, and 1991 when FIT performed a drive-by inspection (2).

Freon-11 was detected in a soil sample from a boring drilled at another building within the complex, not at the Zeta site (66). According to the Zeta facility manager, Zeta used Freon in two 10-gallon degreasers located indoors (68). There were no reported spills, leaks, or releases from the Zeta facility (51).

5. HRS FACTORS

The Hazard Ranking System (HRS) is a scoring system used to assess the relative threat associated with actual or potential releases of hazardous substances from sites. It is the principle mechanism EPA uses to place sites on the National Priorities List (NPL). FIT has evaluated the following HRS factors relative to this site.

5.1 Waste Type and Quantity

Zeta manufactured microwave communication components systems and generated spent chemical baths, paint wastes, and rinse waters containing dilute amounts of chemicals. Table 2 shows waste types and quantity generated by Zeta on an annual basis (49). These wastes were stored or treated in solid waste management units described in section 4.

Table 2. Waste Types and Quantity Generated By Zeta Labs on an Annual Basis.			
WASTE	GALLONS PER YEAR		
Paint sludge and thinners	165		
Spent alkalies	100		
Spent acids	200		
Spent plating baths	110		
Cyanide wastes	40		
Freon solvent wastes 780			
Treatment sludge 700			

In 1986, soil sampling was performed when the neutralization tank was removed. The location of the sampling was directly beneath the point where the effluent stream entered the tank, approximately two feet below ground surface. No background samples were taken. Metals present in the waste stream were found in the soil, however, most of the levels were within the range of naturally occurring background levels and they did not exceed state action levels. Analytical results with corresponding action levels are presented in Table 3 (43,66,70). According to the facility manager, there were no releases from this unit (51).

In 1989, an environmental assessment was performed on the site as part of a commercial property transaction of the 3-building San Thomas Business Park. Soil borings were drilled and samples were taken at three different locations, each location adjacent to a building within the complex. These borings were later converted into groundwater monitoring wells, from which groundwater samples were drawn. During the soil sampling, no organic vapors from the soil cuttings were detected. No petroleum hydrocarbons, gasoline constituents, VOCs, pesticides or PCB's were detected in site soil and groundwater. Samples were not analyzed for metals (66).

Table 3. Results of soil sampling beneath the connection to the sump (mg/kg)				
Constituent	Natural Levels (ppm)	Level detected (ppm)	TTLC (ppm)	
Cadmium	1.0	0.10	100	
Chromium	5-1000 (range)	6.28	500	
Cobalt	1-40 (range)	8.38	8,000	
Copper	2-100 (range)	15.20	2500	
Iron		1456		
Gold	2-1,000 (range)	0.42		
Lead	2-200 (range)	11.72	1000	
Nickel	5-500 (range)	19.76	2000	
Zinc	10-300 (range)	17.16	5000	
Sulfate		250		
Chloride		44		
Nitrate		21		
Phosphate		2.7		
Flouride		22		

5.2 Groundwater

The Santa Clara Valley is a large structural depression filled with alluvial and lacustrine deposits (9). These deposits are predominantly organic-rich clay and silty clay (10). In the northern portion of the Valley where the site is situated, the water-bearing strata are grouped into the upper and lower aquifers (1,9,10). Groundwater at the site is encountered at a depth of 15 to 20 feet bgs and flows to northeast (66). Water in the upper aquifer is unconfined and is separated from the lower aquifer by unconsolidated, course-grained sands

and gravels, and a clay layer approximately 40 feet thick (11,66). Groundwater in the upper aquifer system is not known to have any beneficial uses (9). The lower aquifer system in the area is found at a depth of approximately 200 feet bgs (1,9,11,13). The net annual precipitation in the Santa Clara area is approximately 6 inches (15).

There are several municipal drinking water wells in the Santa Clara Valley which have been contaminated with industrial chemicals. These wells serve as points of documented hydraulic interconnection between the upper and the lower aquifer systems. One of these wells, Santa Clara municipal well #20-02, is located within 2 miles of the Zeta site (1,9,13,16).

Four water purveyors operate groundwater wells that are located within 4 miles of Zeta. They are the City of Santa Clara Water Department (SCWD), the City of San Jose Municipal Water District (SJM), the California Water Service Company (CWSC), and the City of Sunnyvale, Department of Public Works (SDPW). These purveyors operate a total of 75 wells, 43 of which are within 4 miles of Zeta. These wells draw from the lower potable aquifer system at depths ranging from approximately 200 feet to 880 feet bgs (1,50,55,56,57,58,59). A list of water purveyors and municipal wells is presented as Table 4.

	Table 4 Water Purveyor Information								
Water Purveyor						ed	Total Number	Percent Surface	Total Population
	0-1/4	1/4-1/2	1/2-1	1-2	2-3	3-4	In Used by by		Served by System
SJM	0	0	0	0	2	2	13	98%	80,000
SDPW	0	0	0	0	3	3	11	60%	90,000
cwsc	0	0	0	0	0	6	34	67%	69,500
SCWD	0	0	0	7	12	9	27	20%	90,000

The nearest drinking water well to the site is SCWD well #21, located approximately 1 mile southwest of the site. This well was part of an integrated system of 27 wells which blend 80% groundwater with 20% surface water from the Hetch-Hetchy Project and other surface water systems outside the Santa Clara Valley (56,58,60). All 27 wells in this system are located within 4 miles of Zeta. This water system supplies drinking water to a population of approximately 90,000 residents in the city of Santa Clara (see Table 4)(1,17,18).

Currently, there are 13 operating wells in 4 SJM systems; 4 of these wells, which provide water to all four systems, are located within 4 miles of Zeta. Two of these systems are supplied by groundwater only and the other two are served by both groundwater and surface water. The supply ratio for the SJM district is is 98% Hetch-Hetchy Project surface water

and 2% groundwater. The 4 systems serve approximately 80,000 residents (see Table 4) (52,55).

CWSC obtains 67% of its drinking water supply from the Hetch-Hetchy system and the remaining source is obtained from 34 groundwater wells, 6 of which are located 3 to 4 miles from Zeta. CWSC serves an estimated population of 69,500 (61,62,63) (see Table 4).

An estimated 60% of SDPW drinking water is provided from surface water, some of which comes from the Hetch Hetchy Project. The remaining 40% is produced from 11 groundwater wells, 6 of which are located within 2 to 4 miles of Zeta. SDPW serves an estimated total population of 120,000 people (see Table 4) (54,65).

In 1989, an environmental assessment was performed at the site as part of a commercial property transaction of the 3-building San Thomas Business Park. During this assessment, three soil borings were developed into monitoring wells. One of these wells, MW-1, was located in the parking lot behind the Zeta building, downgradient of the neutralization sump/system, and upgradient of the chemical waste storage area (See Figure 2). The other two wells, MW-2 and MW-3, were located downgradient of Zeta at the other buildings in the business park. No wells were placed upgradient of the Zeta site (66).

Trichlorotrifluoroethane (Freon 113) and a by-product of Freon were detected in water samples taken from the 3 wells. The consultant performing the assessment concluded that Freon 113 had migrated on-site from an upgradient source. In addition, levels of Freon 113 detected in groundwater underlying the site were several order of magnitude below proposed drinking water standards (66). No petroleum hydrocarbons, gasoline constituents, pesticides or PCB's were detected in site soil and groundwater. Samples were not analyzed for metals. Sample results are presented as Table 5 (66). Freon 11 was detected in soils at another building within the business park where Zeta is located, but not at the actual Zeta site (66).

Table 5. Freon 113 levels detected in groundwater at San Thomas Business Park (μg/l)			
COMPOUND MW-1 (Zeta) MW-2 MW-3 (downgradient) (downgradient)			
Freon 113	15	18	13

Based on the presence of groundwater contamination and the shallow depth to groundwater, there appears to be a high potential to release to groundwater.

5.3 Surface Water

There is no downslope surface water body to the Zeta site. The elevated Bayshore Freeway would preclude any possible releases to Saratoga Creek, which is an intermittent creek located approximately 0.25 miles south of the site (1,67). The creek flows into south San

Francisco Bay approximately 12 miles downstream from the site (1). There are no known beneficial uses of Saratoga Creek (67). Beneficial uses of the bay include contact water recreation, wildlife habitat, fish spawning and migration, and habitat of endangered species (22). There is no commercial fishing in the south San Francisco Bay area, however, sport harvesting of shellfish is known to occur (23,24). Several federally designated endangered species are present in the bay including the California clapper rail (Rallus longirostris obsoletus), the Salt marsh harvest mouse (Reithrodontomys raviventris), and the California least tern (Sterna antillarum browni) (25). The 2-year, 24-hour rainfall in the Santa Clara area is approximately 2 inches (26). The site is located in a 100-year flood plain (1,27). Due to a lack of a downslope surface water body, the potential for a release from the site to surface water route currently appears to be low.

5.4 Soil Exposure

The Zeta site is located in a high technology industrial area in the northeastern part of Santa Clara (1). Approximately 6,500 people live within one mile of the unfenced site (2,28). The potential for an on-site exposure incident appears to be low because the site is currently paved and landscaped with grass and trees, and known waste sources have been removed.

5.5 Air

The site is mostly paved, with some areas of landscaping that consist of grass and trees (2). Approximately 189,700 residents live within 4 miles of the site. The population distribution within 4 miles of the site is presented in Table 6 (28).

Table 6. Population Distribution Within 4 Miles of the Zeta Site				
Distance from the site	Population			
On site	250			
0 - 0.25 mile	390			
0.25 - 0.5 mile	755			
0.5 - 1 mile	6,040			
1 - 2 miles	30,841			
2 - 3 miles	55,721			
3 - 4 miles	95,704			

The current potential for release from the site via the air route appears to be low because the site is currently paved and landscaped with grass and trees, and known waste sources have been removed.

6. SUMMARY OF FIT INVESTIGATIVE ACTIVITIES

Upon recommendation of the EPA Site Assessment Manager, FIT did not conduct a site visit or interview at Zeta (41). FIT did conduct a drive-by survey to obtain photographic documentation of current occupancy and the removal of the waste storage area (2). FIT contacted DHS, RWQCB, BAAQMD, the Santa Clara County Fire Department, the facility operator for Zeta, and current and past property owners and tenants to obtain file information on the site.

7. EMERGENCY RESPONSE CONSIDERATIONS

The National Contingency Plan [40 CFR 300.415 (b)(2)] authorizes the Environmental Protection Agency to consider emergency response actions at those sites which pose an imminent threat to human health or the environment. Emergency removal considerations at the Zeta site do not appear to be necessary at this time, due to an apparent lack of hazardous substances currently located at the site.

8. SUMMARY OF HRS CONSIDERATIONS

Zeta Laboratories was a manufacturer of microwave communication components systems and printed circuit boards. Wastes generated at Zeta included spent chemical baths, paint wastes, rinse waters, and metal sludges. Zeta applied filed a part A application in 1981 and requested a variance from the ISD. The variance was granted one year before Zeta vacated the facility following closure activities in 1987. The site is currently occupied by 3 businesses that reportedly do not use hazardous substances.

Groundwater is found at a depth of 15 feet below ground surface at the Zeta site. The site is underlain by two aquifer systems, an upper non-potable aquifer system and a lower potable aquifer system. The upper aquifer is separated from the lower aquifer by 200 feet of soils, including a 40-foot thick clay aquitard. However, Zeta lies within 2 miles of a municipal well that serves as a point of demonstrated aquifer interconnection. Within 4 miles of the site, water from the lower aquifer is supplemented with surface water for drinking by over 200,000 residents in the cities of Santa Clara, Sunnyvale, and San Jose. These residents are served by 4 water purveyors. The nearest drinking water well, Santa Clara Municipal Well #21, is located approximately 1 mile southwest of the site. Based on the presence of groundwater contamination and the shallow depth to groundwater, there appears to be a high potential to release to groundwater.

There is no downslope surface water body to the Zeta site. The elevated Bayshore Freeway would preclude any possible releases to Saratoga Creek, which is an intermittent creek located approximately 0.25 miles south of the site. Because of this, there is no indication that a potential for a release via the surface water route currently exists.

The Zeta site is located in a high technology industrial area in the northeastern part of Santa Clara. Approximately 6,500 people reside within 1 mile of the site and approximately 189,700 within 4 miles of the site. The site is mostly paved, with some areas of landscaping that consists of grass and trees, and is not fenced. There is no information to indicate the release of uncontained hazardous waste to air has occurred, and there is a current lack of waste on site. The potential of an on-site soil exposure incident or a release to air appears to be low.

The significant HRS factors associated with the site are:

- There is a shallow depth to groundwater,
- groundwater serves as drinking water to a large population, and
- substances stored on-site had a high toxicity.

9. EPA RECOMMENDATION

	Initial	Date 8-2-91
No Further Remedial Action Planned (CERCLA)	<u></u>	8-2-21
Higher Priority SSI (CERCLA)		
Lower Priority SSI (CERCLA)		
Defer to Other Authority		
(e.g., RCRA, TSCA, NRC)		

Notes:

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APPENDIX A

Contact Log

and

Contact Reports

PA/SI Contact Log

Facility Name: Zeta Laboratories
Facility ID: CAD049233570

Name	Affiliation	Phone #	Date	Information	
*Larry Disgue	City of Sunnyvale	(408) 730-7500	04/06/87	See Contact Report	
*Dave Thomas	California Department of Fish and Game	(415) 688-6340	10/17/89	See Contact Report	
*Alex Sandigo	City of Sunnyvale	(415) 730-7800	11/10/89	See Contact Report	
*Paul Reiley	California Department of Fish and Game	(415) 688-6340	11/13/89	See Contact Report	
*Mike Dulude	City of Santa Clara	(408) 984-3183	11/13/89	See Contact Report	
*Greg Eager	California Department of Health Services	(415) 540-2158	11/14/89	See Contact Report	
*Dennis Ma	City of Santa Clara	(408) 984-3183	11/14/89	See Contact Report	
*Bob Kenton	City of San Jose	(408) 277-4218	12/05/90	See Contact Report	
*Tim Town	City of San Jose	(408) 277-3671	12/21/90	See Contact Report	
*Bob Kenton	City of San Jose	(408) 277-4218	02/01/91	See Contact Report	
*Clay Scoffield	California Water Service Company	(415) 367-6800	02/28/91	CWSC obtains surface water from Hetch-Hetchy.	
*Rick Steel	California Water Service Company	(415) 968-1686	03/04/91	CWSC serves an estimated 69,500 residents.	
Debra Webb	Bay Area Air Quality Management District	(415) 771-6000	04/03/91	BAAQMD has no file information on Zeta Labs	
Doug Hansen	City of Santa Clara Fire Department	(408) 984-3084	04/03/91	The Fire Department required Zeta to file a hazardous substance inventory, and they have no record of any violations issued to Zeta.	
Dave Rist	Santa Clara County Environmental Health	(408) 299-6930	04/03/91	There is no file information Zeta Labs	

^{*} Past Contact Report Used to Evaluate Current Site

PA/SI Contact Log (continued)

Facility Name: Zeta Laboratories
Facility ID: CAD049233570

Name	Affiliation	Phone #	Date	Information	
Bruce Wolfe	Regional Water Quality Control Board	(415) 464-0797	04/03/91	RWQCB does not have a file on Zeta Labs	
Walter Baum	California Department of Health Services	(415) 540-3957	04/15/91	See Contact Report	
"Cindy"	Cabokit	(408) 496-5800	04/16/91	See Contact Report	
"Ronata"	Ultracision	(408) 980-0666	04/17/91	Ultracision is located at 3310 Montgomery St. (same building as Zeta). Ultracision assembles robotic machinery, and does not handle hazardous materials or waste.	
Alan Klein	Cypress Realty	(408) 980-2500	04/18/91	See Contact Report	
*Dennis Ma	City of Santa Clara	(408) 984-3183	04/18/91	See Contact Report	
Rachel Loftin	U.S. E.P.A.	(415) 744-2348	04/26/91	See Contact Report	
Sharie Dunn	The Rreef Fund	(408) 744-1204	04/30/91	See Contact Report	
Rachel Sanoff	Cypress Realty	(408) 980-2500	05/01/91	3265 Scott Blvd. is owned by Rosenberg Real Estate Equity Fund II of Sunnyvale. The property is leased to Ultrasonics, and Cypress which subleases its share to Sonictron and Cabokit.	
Chuck Coady	Lucas/Zeta	(408) 434-3693	05/29/91	See Contact Report	
Chuck Coady	Lucas Zeta	(408) 434-3693	06/25/91	Zeta had two degreasers that each held an estimated 10 gal. of "Freon TF" and generated an estimated 15 gal/week total of waste.	

^{*} Past Contact Report Used to Evaluate Current Site

SITE DRIVE-BY OBSERVATIONS REPORT

ICF Technology, Inc.
Field Investigation Team (FIT)
160 Spear Street, Suite 1380
San Francisco, CA 94105
(415) 957-0110

OBSERVATIONS MADE BY:

DATE: April 11, 1991

Timothy Swillinger, ICF Technology Inc.

SITE NAME: Zeta Laboratories EPA ID#: CAD049233570

The following observations were made during the site drive-by:

Zeta Laboratories no longer occupies the building at 3265 Scott Boulevard in Santa Clara. This address is currently occupied by Sonictron, Inc. The building is located on the corner of Scott Boulevard and Montgomery Street, in a high technology industrial area of Santa Clara. The building has other occupants with a separate address (but still part of the same building): Cabokit, Inc., and Ultracision, Inc., located at 3310 Montgomery.

The site is paved except for landscaped areas in the front which consist of grass and tress. There is no sign of stressed vegetation. Behind the facility is a parking lot. Based on photographs and a facility layout map obtained from California Department of Health Services (DHS) file information, it appears that the previous hazardous waste storage area located behind the facility has been removed and paved over and is now used as a parking lot. This is consistent with the final inspection performed by the City of Santa Clara Fire Department and approved by DHS. Currently, there are no indications of hazardous materials use or storage outside of the building.

CONTAC	r report

	4 484.0 COM 444.		
Agency/Affiliation:	City of Sunnyvale		
Department/Region:		· · · · · · · · · · · · · · · · · · ·	
Address/City:	221 Commercial Street, Sunn	yvale	
County/State/Zip:	Santa Clara County, CA 9408	6	
Contact		Title	Phone
Larry Disgue			(408) 730-7500
ICF Person Making Contact: Tom Beer, Ecology & Environment Date: April 6, 1987			
Subject: Sunnyvale Groundwater Wells			
	ratories (From: Technical CAD009118506)	EPA ID#	: <u>CAD049233570</u>

City wells supply all of the city of Sunnyvale. At present, wells supply 26% of the water. Forty-eight percent of the water is from the Hetch-Hetchy; and the remaining 26% from the santa Clara Valley Irrigation district. The wells are in a fully integrated supply system with 30,000 metered service connections. The wells are perforated from 250 to 700 feet.

1. In 1986, an old 12 inch agricultural well near the corner of Moffett Park Drive and Borregas Avenue started artesian flow. The hole was plumbed to a depth of 240 feet.

CONT	ACT REPORT

	C(NTACT REPORT		
Agency/Affiliation:	California De	partment of Fish and Game		
Department/Region:				
Address/City:	411 Burgess I	Drive, Menlo Park		
County/State/Zip:	San Mateo, C	CA 94025		
Contact		Title		Phone
David Thom	ıas	Marine Biologist		(415) 688-6340
ICF Person Making Contact: Janine Young Date: October 17, 1989 Subject: Commercial Fishing in the South Bay Site Name: Zeta Laboratories (From: Monsanto Chemical Company, CAD009156290) EPA ID#: CAD049233570				
for bait. A smaller industry in w	vhich fish is car	d Santa Clara County is for bught for human consumption information available regardi	n is the s	hark and stripe bass

annually.

For more information on Bay Shrimp, call Paul Reiley of Region 4.

Agency/Affiliation:

City of Sunnyvale

Department/Region:

Public Works Department

Address/City:

221 Commercial Street, Sunnyvale

County/State/Zip:

Santa Clara County, CA 94086

Contact	Title	Phone
Alex Sandigo	Department Supervisor	(408) 730-7800

ICF Person Making Contact: Yoon K. Toh

Date: November 10, 1989

Subject: Water Supply to City of Sunnyvale

Site Name:

Zeta Laboratories

(From: Safety-Kleen Corporation,

CAD077187888)

EPA ID#: <u>CAD049233570</u>

The City of Sunnyvale drinking water is blended from three sources:

- 1. Ten active municipal wells;
- 2. Hetch-Hetchy project; and
- 3. Santa Clara Valley Water District (SCVWD) which gets its water from Lexington Dam, Stevens Creek, Sacramento Delta, San Felipe Reservoir.

No surface water bodies in the city are used for drinking water purposes. The population of the city of Sunnyvale is approximately 120,000.

Agency/Affiliation: California Department of Fish and Game

Department/Region: Marine Resources Division

Address/City: 411 Burgess Drive, Menlo Park

County/State/Zip: San Mateo, CA 94025

Contact	Title	Phone
Paul Reiley	Marine Biologist	(415) 688-6340

ICF Person Making Contact: <u>Joe Lukas</u> Date: <u>November 13, 1989</u>

Subject: Bay Shrimp

Site Name: Zeta Laboratories (From: Monsanto

Chemical Company, CAD009156290)

EPA ID#: <u>CAD049233570</u>

- 1. Bay Shrimp is used solely for bait (there are verbal reports that numerous people are purchasing the bait shrimp for food).
- 2. Three types of shrimp are caught in the south bay:
 - a) Bay Shrimp (up to 90% are caught in this area);
 - b) Korean shrimp (found in brackish water around the Alviso Slough area up to 50% are caught in the south bay); and
 - c) Blacktail.
- 3. Bay shrimp are caught by operators in the following areas:
 - a) Alviso Slough
 - b) Redwood Creek-south of San Mateo Bridge
 - c) Carquinez Straits

Agency/Affiliation:

City of Santa Clara

Department/Region:

Water Department

Address/City:

1500 Warburton Avenue, Santa Clara

County/State/Zip:

Santa Clara County, CA 95050

Contact	Title	Phone
Mike Dulude	Engineering Aid	(408) 984-3183

ICF Person Making Contact: Yoon K. Toh Date: November 13, 1989

Subject: Water Supply to the City of Santa Clara

Site Name:

Zeta Laboratories

EPA ID#: CAD049233570

(From: Safety-Kleen, CAD077487888)

The City of Santa Clara drinking water is blended from three sources:

- 1. 28 active municipal water wells;
- 2. Hetch-Hetchy Project; and
- 3. Santa Clara Valley Water District

There are a total of 28 active wells in the city of Santa Clara. Wells #31 and 23 have not been drilled. Well #33 has been drilled but is not active yet. The active wells are: 2-02, 3, 4, 5-02, 6, 7, 8, 9-02, 10, 11, 12, 13-02, 14, 15 16-02, 17-02, 19, 20-02, 21, 22-02, 22-03, 23, 24, 25, 26, 28, 29, 30.

The population of the city of Santa Clara is approximately 90,900.

Agency/Affiliation: California Department of Health Services

Department/Region: Water Supply Division

Address/City: 2151 Berkeley Way, Berkeley

County/State/Zip: Contra Costa County, CA 94704

Contact	Title	Phone
Greg Eager	Sanitary Engineer	(415) 540-2158

ICF Person Making Contact: Yoon K. Toh Date: November 14, 1989

Subject: Information on Santa Clara Valley Creeks

Site Name: Zeta Laboratories EPA ID#: CAD0492233570

(From: Safety-Kleen, CAD077187888)

All the creeks in Santa Clara Valley are seasonal creeks. None of the creeks and rivers are used for drinking, irrigation, food preparation, or industrial purposes. All these creeks are used as storm drains and are controlled by Santa Clara Valley Water District (SCVWD) for flood control. No average flow is available on any of the creeks or rivers.

Both bermed streams, Coyote Creek and Guadalupe River are used for recreational fishing for Steelhead. There are signs indicating that the creeks and rivers are possibly contaminated, however, some occasional fishing activity has been noted.

Agency/Affiliation:

City of Santa Clara

Department/Region:

Public Works Department

Address/City:

1500 Warburton Avenue, Santa Clara

County/State/Zip:

Santa Clara County, CA 95050

Contact	Title	Phone
Dennis Ma	Senior Water Engineer	(408) 984-3183

ICF Person Making Contact: Yoon K. Toh

Date: November 14, 1989

Subject: File Search

Site Name:

Zeta Laboratories

EPA ID#: CAD0492233570

(From: Safety-Kleen, CAD077187888)

There are currently 28 active wells in the City of Santa Clara. One of the wells, SC1-02 is currently on standby and is not in service but could be. No contaminants have been detected in this well. Contaminants were detected in two municipal wells in 1984 but the concentration was below State Department of Health Services Water Quality Standard for drinking water criteria.

> Well Contaminant Detected Status

SC-24 Freon-113, Cis-1, 2-DCE **Active** SC20-02 1, 1, 1-TCA Active

These wells were never closed because the concentration of contaminants in the wells did not exceed limit for drinking water criteria. Water from municipal wells in the City of Santa Clara is blended with water imported from Hetch-Hetchy system and Santa Clara Valley Water District to serve the population of Santa Clara of approximately 90,000.

CONTACT REPORT

Agency/Affiliation:

City of San Jose

Department/Region:

Municipal Water District

Address/City:

3025 Tuers Road, San Jose

County/State/Zip:

Santa Clara, California 95121

Contact	Title	Phone
Bob Kenton	Water Engineer	(408) 277-3671

ICF Person Making Contact: Belinda Peters Date: December 5, 1990

Subject: Water supply information for the city of San Jose

Site Name:

Zeta Laboratories (From: Keystone

EPA ID#: <u>CAD049233570</u>

Consolidated Industries,

CAD009141433)

The San Jose Municipal Water District (SJM) supplies water to the Alviso, Coyote, Evergreen, and northern (Northeast of Highway 101) areas of San Jose. The population served is approximately 80,000 residents. SJM is divided into 4 service areas: 2 are served solely by groundwater, and 2 (north San Jose and Coyote) are served by both surface water and groundwater. In 1988, the ratio of surface to groundwater was 88% to 12%, and in 1989, the ratio was 98% to 2%. Less water is being pumped now due to the drought. None of the groundwater wells pump greater than 40% of the total production. There are 13 wells used, and the wells are not interconnected. Water from this system has industrial as well as drinking uses.

CONTACT REPORT

Agency/Affiliation:

City of San Jose

Department/Region:

Municipal Water District

Address/City:

3025 Tuers Road, San Jose

County/State/Zip:

Santa Clara, California 95121

Contact	Title	Phone
Tim Town	Water Engineer	(408) 277-3671

ICF Person Making Contact: Belinda Peters Date: December 21, 1990

Subject: Groundwater well locations for San Jose Municipal Water District

Site Name:

Zeta Laboratories (From: Keystone

EPA ID#: <u>CAD049233570</u>

Consolidated Industries,

CAD009141433)

The 11 wells in the area of concern are located as follows:

- Four wells are located at the corner of Capitol Expressway and Tuers Road (at the water company office).
- Two wells are located at the corner of Fontanoso and Highway 101 near Blossom Hill Road, on the east side of Coyote Creek.
- One well is located on Bailey Avenue west of Monterey Highway near the railroad tracks.
- Two wells are located on the south side of Montegue Expressway between Research Place and Zanker Road.

CON	TAC	T	EP.	ORT	
		<i>-</i>			

Agency/Affiliation: City of San Jose

Department/Region: Municipal Water District

Address/City: 3025 Tuers Road, San Jose

County/State/Zip: Santa Clara, California 95121

Contact	Title	Phone
Bob Kenton	Water Engineer	(408)277-3671

ICF Person Making Contact: Belinda Peters Date: February 1, 1991

Subject: Aquifer information for the Santa Clara area

Site Name: Zeta Laboratories (From: Keystone

Consolidated Industries,

CAD009141433)

In the central Santa Clara Valley there are two aquifers. The City of San Jose Municipal Water District uses only water from the lower of these two aquifers as a source of drinking water and their wells only pump water from the lower aquifer. The lower aquifer can be as shallow as 120 feet below ground surface (bgs) in some areas of the valley.

EPA ID#: CAD049233570

In the southern end of the valley, there are 2 other groundwater basins which are not interconnected in any way with the Santa Clara Valley basin. These 2 basins are the Coyote Basin, and the Santa Theresa. The Great Oaks water company, as well as the Edenvale system of SJM both pump water from the Santa Theresa basin. The Coyote system of SJM pumps from the Coyote basin which is a perched water table located along Monterey Road in south San Jose. In this basin, the water is so prolific, that at some points it reaches the surface.

	CO	NTACT REPORT			
Agency/Affiliation:	California De	partment of Health Services	s (DHS)		
Department/Region:	Department/Region: <u>Toxics</u>				
Address/City:	700 Heinz St., 2nd Floor Berkeley				
County/State/Zip: Alameda, CA 94710					
Contact		Title		Phone	
Walter Baur	n	Assoc. Waste Mgmt. En	gineer	(415) 540-3957	
ICF Person Making Contact: Timothy Swillinger Date: April 15, 1991 Subject: Zeta Labs					
Site Name: Zeta Laboratories EPA ID#: CAD049233570					

Mr. Baum was the project officer for DHS at Zeta labs. He said the facility looked pretty clean and did not recall any violations associated with hazardous materials or storage. He says he remembers that Zeta occupied the entire building at 3265 Scott Blvd, Santa Clara. He said to check with the Santa Clara County Environmental Health Department, Toxics Control Unit. Contact Bob Holsten at (408) 299-6930.

Mr. Baum said the only sampling that occurred took place when the underground neutralization sump was removed in October 1986.

	CO	NTACT 1	REPORT		
Agency/Affiliation:	Cabokit				
Department/Region:					
Address/City:	3265 Scott Bly	d. Santa Cla	ıra		
County/State/Zip:	Santa Clara, C	California 93	5054		
Contact		Heriota H	Title		Phone
"Cindy"		C	office Manage	r	(408) 496-5800
ICF Person Making Con Subject: 3265 Scott Blvc		willinger		Date: At	oril 16, 1991
Site Name: Zeta Lab				EPA ID#:	CAD049233570

Cabokit occupies less than 4,000 square feet of the building at 3265 Scott Blvd. They are a cable assembly company, and do not handle hazardous materials or waste. Other occupants in the building include Ultra Sonics, and Sonictron. The property manager is "Cypress" and the contact is Alan Klein at (408) 980-2500. She did not know how long Cabokit had been located at 3265 Scott.

		ORT

			1.44	
Agency/Affiliation:	Cypress Real	ty		
Department/Region:				
Address/City:	2175 Martin .	Ave. Santa Clara		
County/State/Zip:	Santa Clara,	California 95050		
Contact		Ti	tle	Phone
Alan Klein		Corpora	e Officer	(408) 980-2500
ICF Person Making Contact: Timothy Swillinger Date: April 18, 1991 Subject: 3265 Scott Blvd.				
Subject: 3265 Scott Blvd		·		
Site Name: Zeta Lab	oratories		_ EPA ID#	: CAD049233570
	~~~~			

Mr. Klein said that Cypress is a tenant at 3265 Scott. They lease 25,000 square feet, and sublease this to Cabokit, which has 5,000 square feet and Sonictron, which occupies 20,000 square feet. He said Sonictron assembles electronic harnesses for cable and does not believe that they handle hazardous material and waste. Cypress has leased the property since 1989. He said if Sonictron will not allow us to inspect, his assistant, Rachel Sanoff, will lead us on a tour of the facility.

CONTACT REPORT	

Agency/Affiliation:

City of Santa Clara

Department/Region:

Public Works Department

Address/City:

1500 Warburton Avenue, Santa Clara

County/State/Zip:

Santa Clara County, CA 95050

Contact	Title	Phone
Dennis Ma	Senior Water Engineer	(408) 984-3183

E & E Person Making Contact: Tom Genolio Date: April 18, 1991

Subject: Groundwater use

Site Name:

Zeta Laboratories

EPA ID#: <u>CAD0492233570</u>

(From: Continental Can Company CAT000624643)

All wells generally draw from the same aquifer. The total population served is approximately 90,000. There may be rare instances where, because of unknown aquitards, wells draw from different sources. No one well contributes more than 40 percent of the total water supply. The ratio of surface to groundwater varies considerably from year to year. This year they are relying on more groundwater (about 80 percent).

# CONTACT REPORT

Agency/Affiliation:

U.S. Environmental Protection Agency

Department/Region:

Field Operations Branch

Address/City:

75 Hawthorne St., San Francisco

County/State/Zip:

San Francisco, CA 94105

Contact	Title	Phone
Rachel Loftin	State Assessment Manager	(415) 744-2348

ICF Person Making Contact: Timothy Swillinger Date: April 26, 1991

Subject: Contact with PRP

Site Name: Zeta Laboratories

Ms. Loftin was contacted for a decision on whether an inspection/interview was necessary. I explained that the DHS file search provided quite comprehensive information of facility processes and waste storage. I also explained that the facility vacated the premises in 1987 and all businesses that occupy the building currently do not handle hazardous materials and waste. A drive-by revealed that the old waste storage area has been removed, paved over, and is now a parking lot. Contact with the past DHS project officer revealed that there was never any evidence of uncontained hazardous material or waste. File searches at other agencies revealed no record of violations. Ms. Loftin felt that an evaluation could be made based on current information without any inspection, and advised that I try to fill any data gaps by mail.

EPA ID#: CAD049233570

# CONTACT REPORT

Agency/Affiliation:	The Rreef Funds				
Department/Region:					
Address/City:	155 Moffet Park Dr.	Sunnyvale			
County/State/Zip:	Santa Clara, CA	•			
Contact		Title		Phone	
Sharie Dunn		District Manage	er	(408) 744-1204	
ICF Person Making Contact: Timothy Swillinger Date: April 30, 1991  Subject: Zeta occupation of 3265 Scott Blvd.					
Site Name: Zeta Labo					

Ms. Dunn said Zeta occupied the entire building at 3265 Scott, approximately 30,000 square feet. She said Zeta used very little hazardous materials, and she was present at the final inspection in 1987 with Dave Parker of the City of Santa Clara Fire Dept.

She said Rreef Fund of Palo Alto bought the building sometime between 1977-79 and Zeta already occupied the building. In 1988, they sold the building to Essex property Corp., who conducted an environmental assessment of the site with sampling as part of a property transfer, and the report showed no evidence of hazardous material release to the environment. She does not remember who originally the property was purchased from. Sharon Posner was the contact at Essex (415) 494-3700 at 777 California Ave. Palo Alto, 94304.

CONTACT	REPORT
5150000000000	•

Agency/Affiliation:	Lucas/Zeta								
Department/Region:									
Address/City: 2811 Orchard Parkway, San Jose									
County/State/Zip: Santa Clara/California									
Contact		Title		Phone					
Chuck Coad	y	Facility Manage	er	(408) 434-3693					
ICF Person Making Contact: <u>Timothy Swillinger</u> Date: <u>May 29, 1991</u> Subject: <u>History of operations at Zeta Labs in Santa Clara</u>									
Site Name: Zeta Labora	tories		EPA ID#:	CAD049233570					

Mr. Coady said Zeta was owned by Computer & Communications Technology (CCT) of San Diego. CCT originally leased the building at 3265 Scott Boulevard from the San Thomas Development Company in October 1976. During Zeta's occupation of this property, the property was sold to the Rreef Fund of Palo Alto. Rreef Fund maintained the existing lease with CCT/Zeta. CCT no longer owns Zeta. Lucas/Zeta purchased only the assets of Zeta. Mr. Coady was retained as facility manager at Lucas/Zeta. Mr. Coady estimated the number of employees at the Santa Clara Zeta site at 250. He estimated that the outdoor chemical storage unit and the neutralization sump were installed sometime after the facility began operations in 1977. Other than the storage unit, the sump, and the neutralization system that replaced the sump, he knows of no other hazardous waste management units at Zeta. The storage unit had a concrete floor that was treated with epoxy. To the best of his knowledge, there were never any spills or leaks during Zeta's 10 years at 3265 Scott Boulevard, and no violations were ever issued from any regulatory agency that pertained to hazardous materials or waste. Zeta never exceeded the Maximum Allowable Discharge limits set forth by the San Jose/Santa Clara Water Treatment Facility. At the time of the 1987 closure, Zeta was approved for clean closure, and to the best of his knowledge no soil or groundwater samples were ever taken. Wipe samples were taken when the neutralization sump was removed. Mr. Coady verified that the neutralization system that replaced the neutralization sump consisted of three tanks, that were surrounded with one large secondary containment tray. There were never any releases or leaks into this tray. This system was located indoors. Zeta never had any outdoor storage tanks. The only unit that Zeta managed outdoors was the drum storage area.

# APPENDIX B

Photographic Documentation of 3265 Scott Boulevard Santa Clara, California

Photographs Taken on 04/11/91 by

Timothy Swillinger

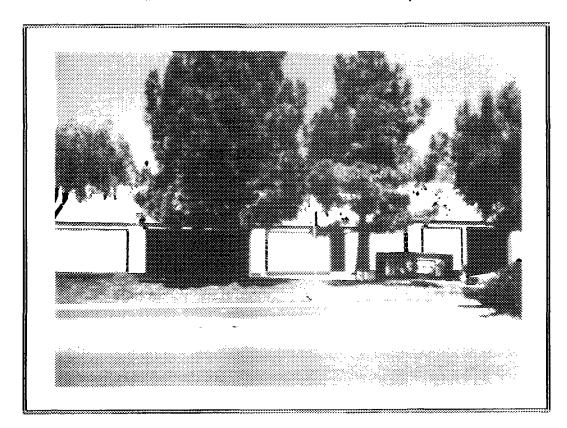


Photo 1: 3265 Scott Boulevard, Santa Clara. Former location of Zeta Laboratories (Facing north).

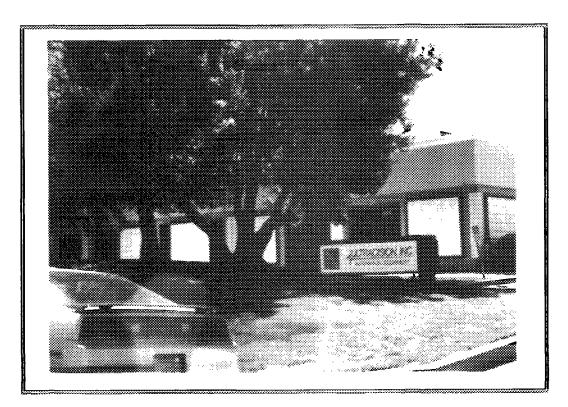


Photo 2: 3310 Montgomery Drive, Santa Clara. Building pictured is the same building located at 3265 Scott Blvd. (Facing southwest).

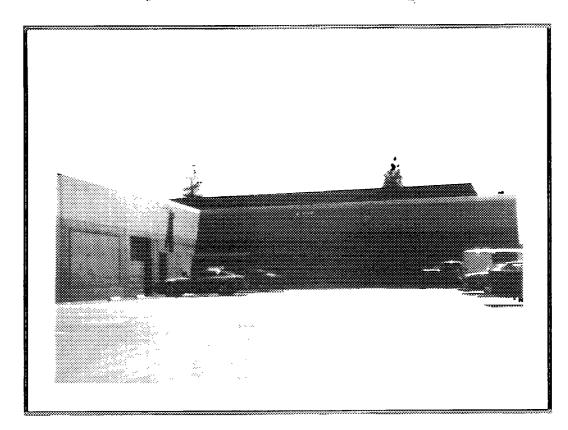


Photo 3: Parking lot behind 3265 Scott Blvd., the previous location of the chemical waste storage area. (Facing South)

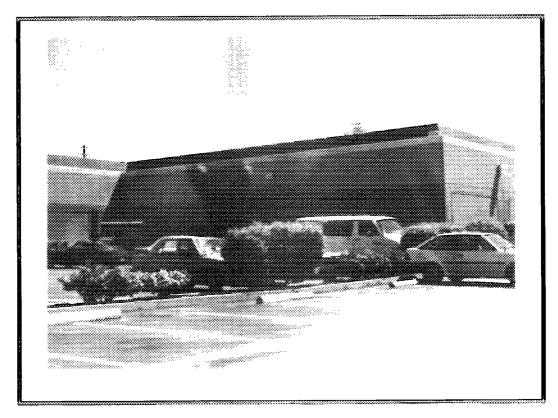


Photo 4: Back side of 3265 Scott Blvd. (Facing southeast)

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NB



DEPARTMENT OF HEALTH SERVICES
2151 BERKELEY WAY
BERKELEY, CA 94704

(415) 540-2043

June 20, 1983

Mr. Austin Terry
Zeta Laboratories
3265 Scott Boulevard
Santa Clara, CA 95051
EPA ID#CAD049233570

Dear Mr. Terry:

The Department of Health Services has received your request for a variance from the Hazardous Waste Facility permit requirements. You are basing your request on one or more of the following statements:

- o You do not store hazardous waste on-site for more than 90 days.
- o Your hazardous waste treatment process is not regulated or is permitted-by-rule under the Resource Conservation and Recovery Act (e.g., neutralization of a corrosive waste in a tank prior to discharge to the sewer system or a wastewater pretreatment system which discharges under permit to a publicly owned treatment works).
- o Your hazardous waste is insignificant as a potential hazard to human health, domestic livestock or wild-life because of its small quantity, low concentration or physical or chemical characteristics.
- o Your hazardous waste is handled, processed or disposed of pursuant to regulations of another governmental agency.

As a result of a preliminary review of your variance request, the Department of Health Services finds that your facility may be eligible for a variance. The variance will be acted on within one year from the date of this letter. Until such time as a variance is acted upon you may continue to operate under the Interim Status Document and do not need to submit the Operation Plan.

Should you have any questions please contact Blake Spears at (415)540-2043.

Sincerely,

Charles A. White, P.E. Regional Administrator

North Coast Region

Hazardous Waste Management Branch

cc: Greg Cummings .
Cummings Environmental

April 18, 1983

Dear Ilr./Illz.

The following is a variance request for Zeta Labs Inc. of Santa Clara. Zeta Labs is not a waste storage or treatment facility, but rather a waste generator.

Zeta excepts no off site waste, it is not a disposal site, it does no treatment beyond simple neutralization, and its' wastes are removed within ninty days.

Respectfully

Grea Cummings

President

Cummings Environmental

for

Zeta Labs Inc.



# REQUEST FOR BAZARDOUS WASTE LACILLY PERMIT VARIANCE

# California Department of Health Services Hazardous Waste Management Branch

I would like to request a variance from the Hazardous Waste Facility Permit requirements of the California State Department of Health Services.

Permit requi	rements of the California State Department of Health Services.
I am request	ing a variance for the following type of facility:
(X)	Container storage
( )	Tank storage
	( ) located above ground ( ) located below ground
( )	A totally enclosed treatment facility.
(X)	An elementary neutralization unit.
(X)	A facility that discharges directly to a POTW.
( ) (	Other (specify)
	is own:ed/operated by Zeta Laboratories, Inc.  ed at 3265 Scott Blud., Santa Clara, Ca. 95051
	ny request for a variance on the following checked (X) sections California Administrative Code:
<b>( ) 663</b> 10(a	a)(1) The hazardous waste at my facility is insignificant as a potential hazard to humans, domestic livestock or wildlife because of its:
	( ) small quantity;
	( ) low concentration; and/or
	( ) physical or chemical characteristics.
<b>(X)</b> 66310(a	(2) The hazardous waste at my facility is handled, processed or disposed of pursuant to regulations of another govern- mental agency:
My firm is re	gulated by the following agency: DOT, EPR, City of Santa
	ta Clara Co. Hazardous Materials Ord.)
	applicable permit is attached.
	TY Sauman wa grandina.

I am attaching information and drawings as outlined in Attachment A in support of this variance request. For any facilities involving underground tanks, I have attached information on a proposed groundwater monitoring program as outlined in Attachment B.

I understand that any variance from the Hazardous Waste Facility Permit requirements of the Department of Health Services, if granted, does not exempt my firm from any other applicable laws and regulations governing the management of hazardous wastes.

I certify that all information submitted with regards to this variance request is true, accurate and complete.

Gregory B. Curmings (Applicant, Typed or Print)	<del></del>
(Signature) Cuming	P.O. Bax 20731, San Jose, Calif (Mailing Address)
President/Cummings Environmental: (Title)	for Zeta Laks
408-252-8372 (Telephone Number)	
April 18, 1983 (Date)	Interim Status Document No.  If Applicable

## 1. Design

- a) types, 55 gallor drums, recently emptied virgin chemical containers.

  containers are metal or polyethylene and are the standard 55 gallon containers used for chemical shipment.
- b) secondary containment: Zeta Labs has just received a bid
  for \$1,463.00 in order to provide a berm (secondary
  containment) around its' hazardous chemical storage
  area.
- c) adjacent property lines, the chamical storage area is 87 feet from one property line and 39 feet form the other adjacent property line.
- 2. Jaste Characteriaztion
  - a)Deoxidizer #3— disulfant of sodium bifluoride of potassium chromic acid

Alodine 1200- chromic acid nitric acid ferrius cyanide

2 drums per year

Tinposit Lt-26- HCI

carboxylic acid kelate thiourea

10 drums per year

etchant- ferric chloride HC1 copper lead

3 drums per year

Spent nickel bath- nickel sulfate nickel sulfate nickel chloride boric acid
4 drums per year

b) volume- spent chemicals are placed in 55 gallon drums, there is no problem with design capacity and average capacity.

drums are placed in a hazaradous materials area with a capacity large enough to contain the drums until shipment to chemical disposal area.

- b) storage area is designed to contain about 30 drums, more capacity than Zeta labs produces in a year. With spent chemical shipments every 60 to 75 days there would seldom be more than 6 drums in this storage area.
- b) spent chemicals are compatible with containers as spent chemicals are placed in x-virgin chemical containers.

#### 3. Process

- a) source- spent deoxidizer, tinposit, spent nickelbath, and spent Alodine 1200 are all generated from platting processes.

  spent ferric chloride etchant is from an etching process.
- b) handling methods(generating to storage): spent baths are pumped into 55 gallon drums and then moved to spent chemical storage area.

  (storage to disposal): 55 gallon drums containing spent chemicals are removed from the spent chemical storage area to the dump site by C.L. Scott Ent. Inc. dba Ultra-Chem.
- c) ultimate disposition- spent chemicals are taken to the Kettleman
  Hills chemical dump by Ultra-Chem(waste
  haulers).

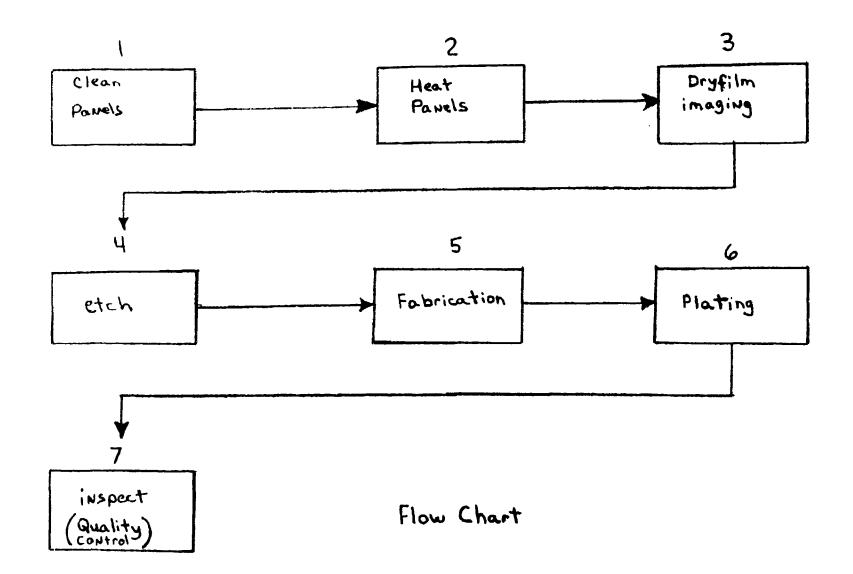
#### 4. Operational Procedures-

- a) site security— spent chemical area is clearly signed, fenced, and locked. It can be seen from 4 rear doors of the facility, the employee parking lot, and is accessible at all times to police patrol vehicles.
- b) personnel safety- training-employees receive on the job training as well as direct quidence by supervisors in the handling of spent chemicals.

  personnel safety- employees are provided with

b) personnel safety- (cont.) OSHA required protective gear.

And an emergency spill procedure has also
been prepared and posted to guide employees
in case of an eccidental spill.



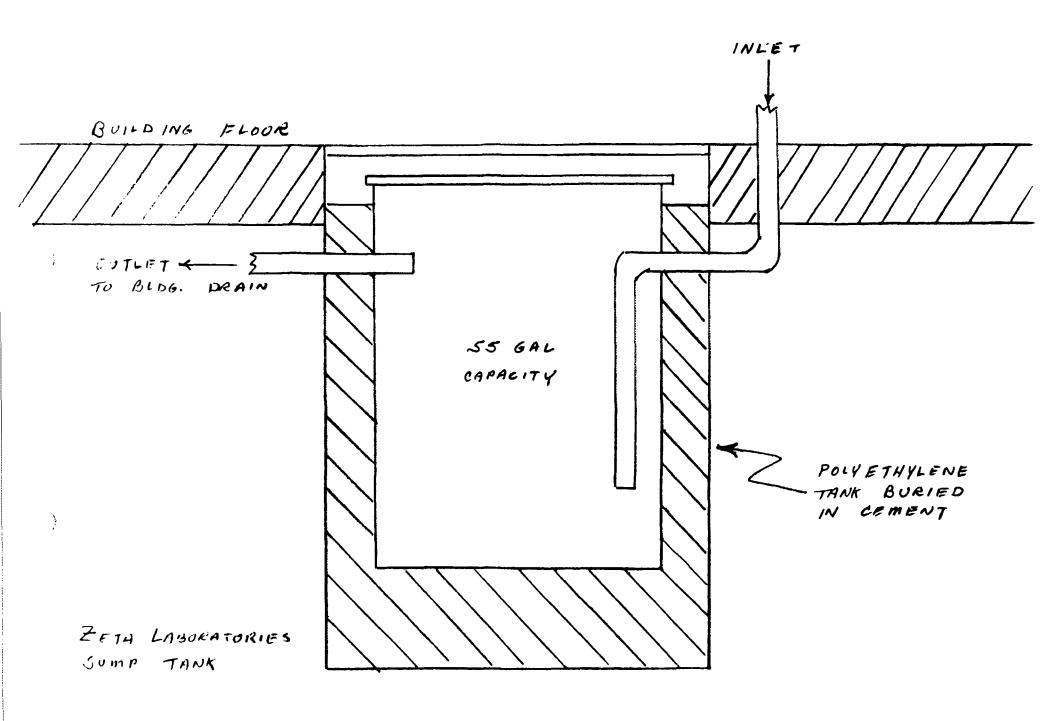
)

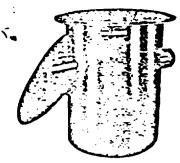
## Neutralization Sump-

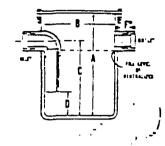
As indicated by the following facilities layout, the 55 gallon neutralization sump is a polyethylene tank encased in concrete (see drawing) which discharges directly to POTW.

The tank is buried in the middle of the machine shop, backing against a wall on the other side of which is the small platting facility.

Our proposal is to close this sump, fill it with concrete and constuct a new neutralization tank outside the building, above the ground, and double contained.









These are heavy-duty tanks, built to withstand the heat of neutralization and the corrosive attack of acids and alkalies. They are molded in one piece from virgin polyethylene, and are inexpensive, unbreakable and easy to install.

Triple-we'ded fittings are molded from the same high grade resins as the tanks. A complete selection of inlet and outlet adapters permit connection to any piping material. Inlet and outlet will be installed at prices indicated below and in positions shown in drawings unless otherwise specified. Prices for inlets and outlets are in addition to tank price.

Inexpensive limestone or marble chunks are used in the neutralization tanks. Successful neutralization involves the resolution of many

factors, including flow rate, volume, composition and temperature of effluent, amount of time exposed to limestone, surface area of limestone.

If burial is necessary, it should be done according to instructions from project engineers or architects.

Neutralization tank extensions are available. Call our Sales Department for prices and specifications.

NOTE: Since effective neutralization is a complex process. Nalge Company recommends the employment of professional assistance to analyze the effluent, recommend appropriate equipment and prescribe necessary maintenance services before ordering neutralization tanks.

#### 97000 Black Conventional Polyethylene Neutralization and Dilution Tanks

- Continuous service to 140°F: intermittent to 180°F
- Open-top design with heavy-gauge bolt-down cover, neoprene gasket and stainless steel nuts, bolts and washers furnished
- 1200 gallon tank furnished with steel-banded wooden girdle for extra strength.
- Inlets and outlets are priced separately (See chart below)



Eleven different sizes—5 to 1200 gallons

Size Code	-0005	-0015	-0030	-0055	-0100	-0150	-0200	-0250	-035 <b>0</b>	-0500	-1200
Cap., gal.	5	15	30	55	100	150	200	250	350	500	1200
Dimension A, in.	16	15	27	33	42	46	46	44	46	60	84
Dimension B, in.	10	18	18	22	28	31	36	42	48	52	69
Dimension C, in.	12	10	22	27	36	38	38	36	38	52	72
Dimension D, in. Apprex. wall	2	2	3	3	4	6	6	6	6	6	8
thickness, in. Usable volume,	316	**	Ж,	₩,	<b>¼</b>	1/4	14	<b>¼</b>	84	<b>%</b>	%
cu. ft. Max. inlet &	0.58	1.33	3.06	5.34	12.00	15.97	20.83	26.51	36.52	61.05	149.24
outlet, in. 97000 Tanks,	2	3	3	4	4	4	6	6	6	, 6	6

Price, each** \$115.00 \$164.00 \$186.00 \$233.00 \$331.00 \$447.00 \$497.00 \$683.00 \$737.00 \$1323.00 \$3494.00 **Price includes tank, cover, nuts, bolts and gasket only. Inlets and outlets are priced separately below.

# B TILL LIFE NO. 181 MALES

#### 97100 Black Linear Polyethylene Neutralization and Dilution Tanks

- Continuous service to 180°F; intermittent to 212°F
- Closed-top design with cover, gasket and stainless steel V-band
- Three sizes—55, 100 and 250 gallon
- Excellent chemical, impact and abrasion resistance

Size Code	-0055	-0100	-0250
Cap., gal.	55	100	250
Dimension A, in.	37	46	50
Dimension B, in.	22	28	42
Dimension C, in.	27	36	36
Dimension D, in.	3	4 .	6
Dimension E. in.	18	18	18
Approx. wall thickness, in.	₹,	<b>½</b>	<b>1</b> /4
Usable volume, cu. ft.	5.0	11.5	25.0
Max. inlet & outlet, in.	4	4	6
97100 Tanks, Price, each*	\$136.00	\$162.00	\$243.00

^{*}Price includes tank, cover and V-band only.
Inlets and outlets are priced separately below

# Inlets and Outlets

To determine the total price of the complete neutralization tank, add the price of each inlet and outlet required to the price of the tank. Inlet includes connecting adapter, elbows and dip pipe. If a vent is required, order any outlet listed in the chart.

Pipe connections consist of plain nipple and installed half coupling for field assembly.









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J150	11/2	\$58.00	414	\$58.00	\$40.00	13%	\$30.00	\$43.00	11/4	\$33.00	\$34.00	134	\$19.00	\$39.00	234	\$22.00
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-0+00 -0500	4	135.00 191.00	634 614	87.00 98.00	95.00	23%	80.00	101.00	2%	87.00	83.00 104.00	21/4	29.00 75.00	91.00	2%	31.00

Zeta Labs is not a hazardous waste facility its' a hazardous waste generator. It has filed with the EPA and a copy of the application follows.

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V. FACILITY DRAWING  All existing facilities must include in the space provided on pa	oe 5 a scale drawin	o of the facility (see instructions	for more di	tail).	
All existing facilities must include photographs (aerial treatment and disposal areas; and sites of future storage	or ground—leve	// that clearly delineate all ex	isting stru	cture	s; existing storage,
FACILITY GEOGRAPHIC LOCATION	e, treatment of				
LATITUDE (degrees, minutes, & seconds)		LONGITUDE	(degrees, r	ninu te	rs, & seconds)
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VIII. FACILITY OWNER	والحروض وأأوالي	· 图 如果的 (如此)		_	
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B. If the facility owner is not the facility operator as lists	ed in Section VIII	on Form 1, complete the follow	ing items:	T	
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3. STREET OR P.O. BOX	ej	4. CITY OR TOWN	5.	ST.	6. ZIP CODE
F	G				
IX. OWNER CERTIFICATION	1000	1.5. 5844	1 100 100		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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IV. DESCRIPTION OF HAZARDOUS WASTE Continued.

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2	. PF	OC	ESS	DE	SCRIPTIC	N: If a code is not li	sted f	for a s	process that will	i be used, de	scribe the p	rocess in the spa	ce provided on th	ne form.
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OR DESCRIBING OTHER PROCESSES (code

100

ACT FOR ADDITIONAL PROCESS CODES

included with above

# DEPARTMENT OF HEALTH SERVICES

2151 BERKELEY WAY BERKELEY, CA 94704 (415) 540-2043



June 4, 1984

Mr. Dick Smith Zeta Laboratories 3265 Scott Boulevard Santa Clara, California 95051

Dear Mr. Smith:

On May 22, 1984 Judy Steenhoven of my staff visited your hazardous waste facility. The purpose of this visit was to inspect the facility for compliance with hazardous waste generator requirements and to review your wastewater neutralization unit for eligibility to receive a variance from permit requirements.

At the time of inspection it appeared that your facility was in compliance with all applicable generator requirements, however you and your consultants, Messrs. John Schultz and Michael Gottsegen of Cummings Environmental, indicated that you intend to reconstruct the container storage area for improved access and containment of the stored materials, as well as replace your existing underground neutralization unit. In order for the Department of Health Services to consider issuing a variance from hazardous waste treatment facility permit conditions, the existing neutralization system must be modified to add a leak detection (groundwater monitoring) system, or an new inspectable system must be installed to replace the existing system.

Please submit a letter to this office by June 22, 1984 indicating improvements to the container storage area. Also resubmit the variance application for the wastewater neutralization unit when the new or modified system has been designed. The Department will further consider issuance of the variance upon receipt of this application.

Should you have any questions regarding this matter please contact Judy Steenhoven at (415) 540-3179.

Sincerely,

Dwight R. Hoenig, Chief

Toxic Substances Control Division

North Coast California Section

John Schultz Cummings Environmental

> Michael Gottsegen Cummings Environmental

DEPARTMENT OF HEALTH SERVICES

2151 BERKELEY WAY BERKELEY, CA 94704



September 20, 1985

Rhonda Brown
Manager of Operation Services
Zeta Laboratories, Inc.
3265 Scott Blvd.
Santa Clara, CA 95051

VARIANCE DETERMINATION CAD 049233570

This is to confirm our conversation of September 16, regarding your variance request of May 1983.

Pending review of construction plans for your proposed neutralization unit, including secondary containment, we must deny your variance request.

A final statement of your intentions is requested by this Department by October 30, 1985. Should you request a variance, all items of Title 22, of the California Administrative Code, Section 66310 are requested by said date. Of particular interest are a description of the waste, including its quantity, physical state, composition, source and production rate.

If you have any questions regarding this matter, please call me at (415)540-3342.

Sincerely,

Walter Bahm

Walt Bah

Waste Management Engineer Toxic Substances Control

Division

North Coast California Section

WB/nt

16620 BOHLMAN ROAD SARATOGA, CALIFORNIA 95070 TELEPHONE (408) 867-7276

June 10, 1987

Bob Campbell
Santa Clara Fire Department
777 Benton Street
Santa Clara, CA 95050

RE: Closure of Zeta Laboratories 3265 Scott Blvd

Dear Bob Campbell:

This letter is to inform you that Zeta Laboratories will be moving from 3265 Scott Blvd to San Jose. Reefe Associates, the building owner, will be taking possession of the facility on July 15.

Zeta Laboratories is a manufacture of microwave components. The facility has a small printed circuit board shop and waste treatment system which will not resume operation after the move. There are no wet floors or underground tanks at the facility (an underground neutralization sump was removed in 1986, permit number P86-72).

The following actions are being taken to insure there will be no residual contaminates before closure of the facility:

- 1) Paints and new chemicals sealed in their original containers, will be transported to the new facility.
- 2) All other chemicals will be sent to a licensed Treatment, Storage, and Disposal Facility.
- 3) The hazardous materials storage areas will be steam cleaned by a company specialized in remeadial action.

- 4) Piping from the plating tanks to the treatment system, and exhaust ducting from the plating and treatment tanks will be disposed of as class one waste.
- 5) The waste treatment system and plating tanks, and their secondary containment trays, will be triple rinsed and/or steam cleaned to remove any contamination. These will be put into storage at the new facility or sold to a plating shop.
- 6) All water generated during steam cleaning and triple rinsing will be collected and disposed of as a class 1 waste.

All work will be done with the appropriate safety precautions, including personal protective gear. Copies of the hazardous waste manifests will be forwarded to your office at the conclusion of the work.

If you have any questions or comments you can contact me at 867-7276 or Chuck Coady at Zeta Laboratories at 727-6002 or 434-3600.

Sincerely,

Suzanne Maionchi

Environmental Consultant



ZETA LABORATORIES, INC. A Subsidiary of CCT Corp. 3265 Scott Blvd. Santa Clara, CA 95054 (408) 727-6001 TWX 910-338-7336

July 30, 1987

The City of Santa Clara Fire Dept. Robert Campbell Chemical Specialist 777 Benton Street Santa Clara, CA 95050

Re: Closure of Facility; 3265 Scott Blvd., Santa Clara

Bob;

Thank you for taking the time to visit Zeta's former facility at 3265 Scott Boulevard to confirm that all of the action items stated in our closure plan, dated June 10, 1987 were completed.

Sincerely,

Chuck Coady

Facilities Manager

cc: S.L. Dunn - RReef

S. Miller - Env. Consultant

jrh/CC

# ZETA LABORATORIES, INC

#### CONTINGENCY PLAN

The Contingency Plan contains actions for personnel in case of fire, explosion, or unplanned release of hazardous wastes or hazardous materials to air, soil, or surface water. The provisions in this plan are to be carried out immediately in such a situation.

Prepared by:

Suzanne Maionchi

Environmental Consultant

#### WASTE ANALYSIS PLAN

#### SOURCE OF WASTES

Zeta Laboratories is a manufacturer of microwave components and printed circuit boards. Chemical wastes are generated from plating and cleaning operations. Two types of wastes are generated from these processes; 1) spent chemical baths, which are waste hauled; and 2) rinse waters containing dilute amounts of these chemicals, which are pretreated before discharge to the local POTW. In addition, paint sludges and waste thinners are generated from painting operations.

#### WASTEWATER TO BE TREATED

Wastewater from the plating processes is generated when parts are rinsed after emersion in a chemical bath. The rinse waters are dilute solutions containing some metals in a total concentration of approximately 5-100 ppm. The rinse water from this process is hard plumbed to the treatment system. In this manner there is strict control of the influent to the treatment system, only materials plumbed to the system will be treated. In the new treatment system, rinse waters from cyanide containing tanks will be piped to a cyanide treatment tank before transfer to the metal precipitation tank of the treatment system. Rinse water from chromium bearing solutions will first go to a chromium reduction tank, before the metal precipitation tank.

Analysis of the wastewater will be carried out on the effluent from the treatment system. Since the wastewater is to be discharged to the POTW, the characteristics of the effluent are important. Analysis of the effluent will give information on the proper functioning of the treatment system, as well as signaling a change in wastewater influent characteristics. The measurement of the effluent is thus more efficient. The components of the waste stream are known from manufactures data on the chemical baths. The parameters of concern are the concentration of metals, cyanide, and the pH.

The following parameters will be monitored monthly:

pH Cyanide Copper Chromium Lead Zinc

The analysis is carried out by a certified laboratory, using EPA methods or the equivalent. Sampling is done at the point of discharge, using an acid washed polyethylene or glass container.

In addition to the monthly analysis, an in-house analysis is performed at least weekly. The parameters mearsured are pH, copper, chromium, and cyanide. Hach test kits and pH paper are used for the analysis.

A increase in the concentration of metals or cyanide indicates improper functioning of the treatment system or an increase in the concentration of the influent. Any concentration over one half of the concentration allowed by the POTW, is noted. At this point the treatment system is inspected for malfunctions and the wastewater generation process is reveiwed. If the concentrations have exceeded the allowable limits, the wastewater discharge is stopped, until the problem has been found and corrected.

	Maximuim Allowable	"Flagged"
Parameter	Discharge mg/l	Concentration
Copper	2.7	1.3
Chromium	1.0	0.5
Zinc	2.6	1.3
Lead	0.4	0.2
Cyanide	1.0	0.5

#### WASTE TO BE DISPOSED OF OFFSITE

Chemical baths and stagnant rinses are periodically replaced. The spent baths and rinses are pumped to a 55 gallon polyethylene drum. Waste paints and thinners are transferred to a metal 55 gallon drum as they are generated. Drums are kept segregated in an outdoor chemical storage area for less than 90 days.

. Jan 🕶 🛥

Wastes, other than the treated rinse waters, are collected by a licensed waste hauler and brought to a permitted treatment, storage, and disposal company. Wastes are disposed of by Solvent Service Inc., Ultra-Chem, or Chemical Waste Management Inc.. The ultimate disposition of the waste is at the class one disposal sites of CWMI Kettleman Hills, or Casmalia Resources. Waste thinners and paints may be reclaimed by Solvent Service or Ultra-Chem.

The types of chemicals in the waste streams are known from the manufactures data on the new product, since the processes do not alter the chemical composition of the wastes, other than changing the concentrations and adding contaminates.

Unless a process changes, a waste analysis will be performed only once yearly on each waste stream type. The analysis will be done by an outside certified laboratory. EPA methods, or the equivalent will be used. Sampling will be through the bung hole of the drum. A coliwasa, or equivalent type sampler will be used, in order to get a vertical sample through the extent of the drum. The parameters measured follow:

PLATING WASTE

SOLVENT WASTE

pН

Flash point

Copper

Total Organic Halogen

Chromium

Percent Water

Fluorides

Lead

The parameters are chosen to verify the waste stream, determine the concentration of restricted material and the recycle value of the solvent waste, and to indicate changes in the waste stream. If a waste stream has changed, the offsite disposal company will be notified, to assure that they can still accept the waste. If the disposal site or the recycler requires additional information in order to store, treat or dispose of the waste, the appropriate analysis will be performed.

#### SOURCE OF WASTES

Zeta Laboratories is a manufacturer of microwave components and printed circuit boards. Chemical wastes are generated from plating and cleaning operations. Two types of wastes are generated from these processes; 1) spent chemical baths, which are waste hauled; and 2) rinse waters containing dilute amounts of these chemicals, which are pretreated before discharge to the local POTW. In addition, paint sludges and waste thinners are generated from painting operations.

Zeta Laboratories is planning to expand its waste generating processes as is shown on the following page. Before these processes are added a new pre-treatment system will be installed. Process flow diagrams are shown on pages 3-9. All processes have a double containment system.

#### HANDLING METHODS

Wastewater from individual processes is hard plumbed to the wastewater treatment system or the municipal sewer, as indicated on the flow diagrams. The effluent from the treatment system is hard plumbed to the municipal sewer.

Chemical baths and stagnant rinses are periodically replaced. The spent baths and rinses are pumped to a 55 gallon polyethylene drum. Waste paints and thinners are transferred to metal 55 gallon drums as they are generated. Drums are kept in the outdoor chemical storage area for less than 90 days.

#### ULTIMATE DISPOSITION

Wastes, other than the treated rinse waters, are collected by a licensed waste hauler and brought to a permitted treatment, storage, and disposal company. Wastes are disposed of by Solvent Service Inc., Ultra-Chem, or Chemical Waste Management Inc.. The ultimate disposition of the waste is at the class one disposal sites of CWMI Kettleman Hills, or Casmalia Resources. Waste thinners and paints may be reclaimed by Solvent Service or Ultra-Chem.

#### OPERATIONAL PROCEDURES

#### SITE SECURITY

The facility is guarded during all non-business hours. The chemical storage area is fenced and kept locked. It is easily accessible to the fire and police departments. NFPA, no smoking, and hazardous waste warning signs are posted outside the storage area. Areas using or storing chemicals are inspected five days per week.

#### PERSONNEL SAFTEY

Employees receive on the job training as well as guidence by supervisors in the handling of chemicals. Material Safety Data Sheets are reviewed by, and available to employees. Personnel using chemicals are trained in the associated hazards of their use, and in emergency procedures and action plans. Employees are also instructed in proper chemical disposal methods.

Chemical spills will be handled in accordance with the recommended procedures on the Material Safety Data Sheet. Protection gear is on hand for handling chemicals or for use in an emergency situation.

#### WASTE MONITORING SYSTEM

The area between the neutralization tank and the concrete casing is not accessible for monitoring devices and cannot be visually inspected. The interior of the tank is inspected when the limestone is removed, on a monthly basis. The neutralization tank should be removed in February, 1986. At this time soil samples of the area surrounding the tank will be taken and analyzed for contamination.

#### SITE HYDROGEOLOGY

This area characteristically has alluvial soils ranging from sandy silts to silty clays. Ground water is usually shallow, the first aquifer may be as shallow as a few feet deep. Ground water may be used for drinking in this area.

Zeta Laboratories is registered with the EPA as a hazardous waste generator. A copy of the application is attached.

# WASTE CHARACTERIZATION

#### WASTE TYPE

Two types of wastes are generated at Zeta Laboratories; 1) spent chemical baths and paint wastes, which are waste hauled; and 2) rinse waters containing dilute amounts of chemicals, which are pretreated before discharge to the local POTW. The chemicals used in the baths are shown in the process diagrams. Most of these chemicals are corrosive and contain heavy metals. Cyanide waste is generated in the gold plating process. This waste is segregated from the corrosive wastes. Flammable paint wastes are also segregated from the corrosive wastes. Wastes from treatment, currently consisting of used limestone rocks, will be in the form of metal hydroxide sludge when the proposed treatment system is in operation.

#### **VOLUME**

The chemical waste storage area is designed to contain 30 drums. It usually holds no more than 15 drums. The approximate amount of waste generated on an annual basis follows:

WASTE	GAL/YEAR
Paint sludge and thinners	165
Spent alkalies	100
Spent acids	200
Spent plating baths	110
Cyanide wastes	40
Treatment Sludge	700

The neutralization system is presently treating a maximum of 1280 gallons of rinse water per day. The proposed treatment system has a capacity of 4800 gallons per day. The expected volume of rinse water that will be generated is 3620 gallons per day.

#### COMPATIBILITY WITH CONTAINERS

Wastes are kept in compatible containers. Corrosive wastes and plating baths are pumped into polyethylene drums. Flammable wastes are put into metal drums.

# DESIGN OF WASTE STORAGE AREA

#### TYPES OF CONTAINERS

Waste is stored in 55 gallon drums which had recently contained virgin material. Standard DOT approved drums are used.

#### CONSTRUCTION MATERIALS

The drums used for corrosive wastes are polyethylene. Metal drums are used for flammable liquid storage. Secondary containment consists of a concrete berm surrounding an asphalt pad.

#### SECONDARY CONTAINMENT

The entire storage area is surrounded by a concrete berm. The storage area is further segregated into corrosive, flammable, and toxic storage areas by additional berming. Additional spill control is provided by a drainage collection sump. The berm and sump capacity is 110% of 30 drums. No more than 15 drums are usually stored at any time.

#### PROPERTY LINES

The chemical storage area is 87 feet from one property line and 39 feet from the other adjacent property line.

#### DESIGN OF PRESENT WASTE TREATMENT SYSTEM

### TYPES OF CONTAINERS

The present waste treatment system is an underground 55 gallon neutralization sump which discharges directly to the POTW. Incoming rinse waters are neutralized by limestone rocks. The tank is approximatly 7 years old. Details are shown on the following pages.

#### CONSTRUCTION MATERIALS

The neutralization tank is made of polyethylene. It is encased in concrete.

#### SECONDARY CONTAINMENT

Secondary containment is provided by a concrete casing around the polyethylene tank, although this does not allow for monitoring between the two containers.

# PROPERTY LINES

The neutralization tank is located inside the building (see the attached plans).

#### DESIGN OF PROPOSED TREATMENT SYSTEM

# TYPES OF CONTAINERS

The largest tank volume will be 350 gallons, the total tank volume will be 890 gallons. The tanks will be new. Tank layout and schematic drawings are attached.

## CONSTRUCTION MATERIALS

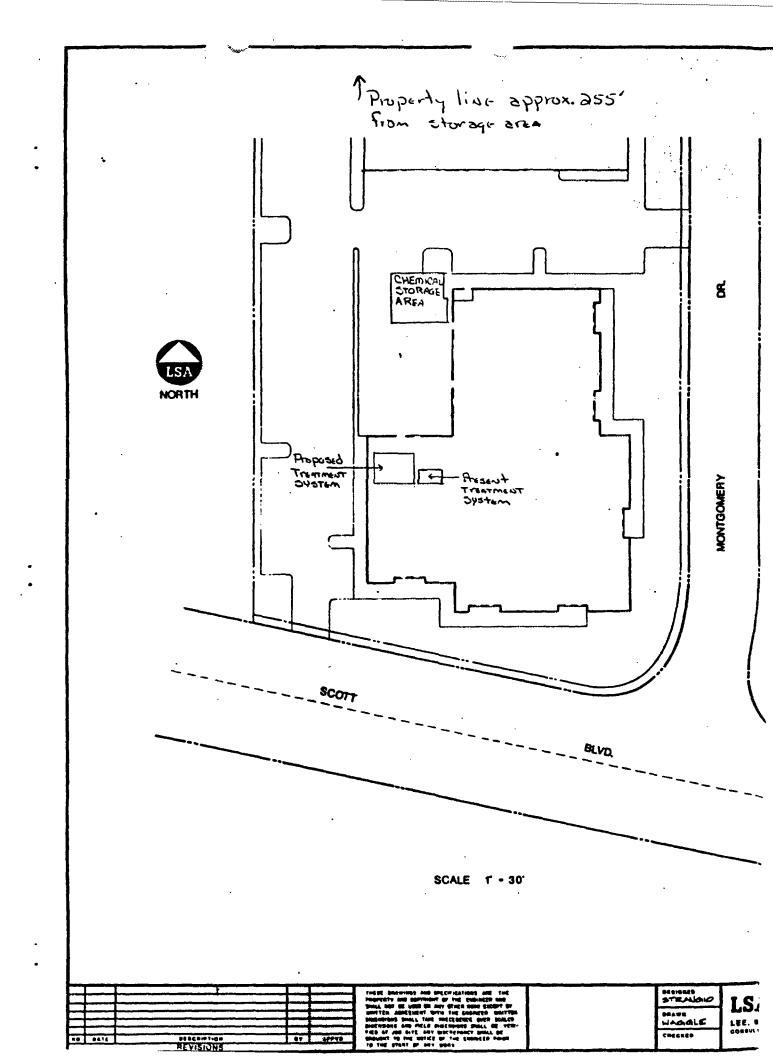
Tanks will be made of polypropylene. The secondary containment system will be made of poly vinyl chloride.

#### SECONDARY CONTAINMENT

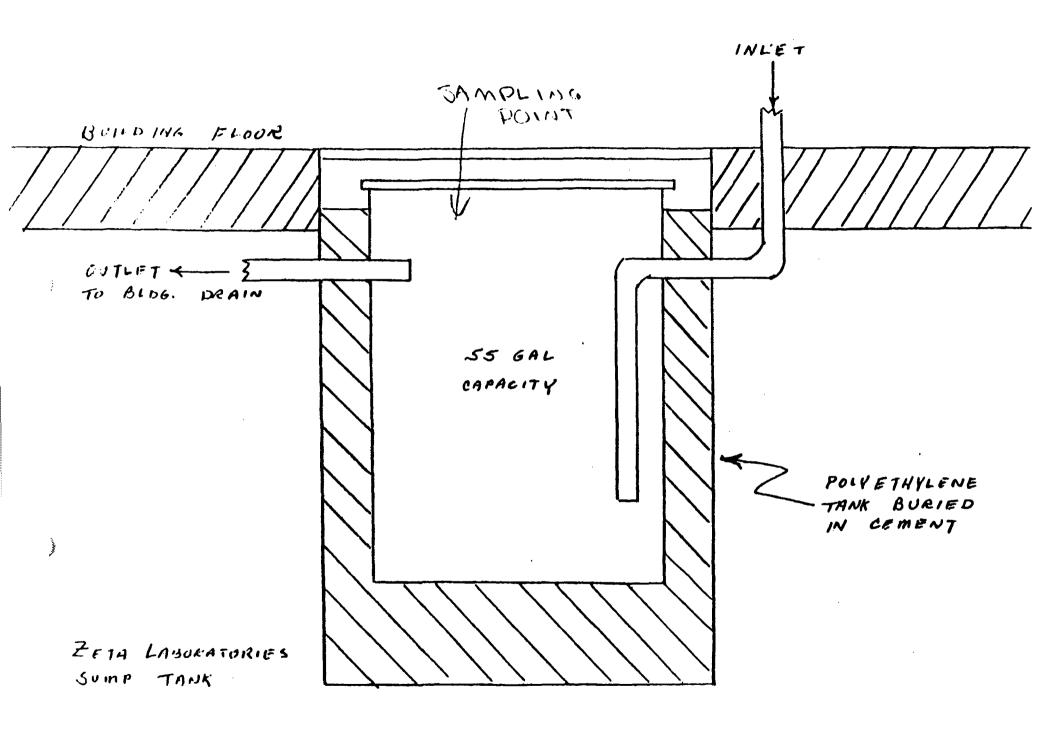
Secondary containment will be installed around the entire treatment system. It will be designed to contain 110% of the total tank volume.

#### PROPERTY LINES

The proposed treatment system will be located inside the building (see the attached plans).

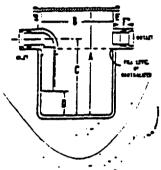


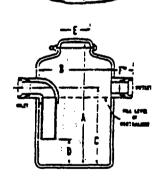
PRESENT
TREATMENT SYSTEM
AND
PROCESS LAYOUT



.







# 9700 ries Neutralization ar

These are heavy-duty tanks, built to withstand the heat of neutralization and the corrosive attack of acids and alkalies. They are molded in one piece from virgin polyethylene, and are inexpensive, unbreakable and easy to install.

Triple-welded fittings are molded from the same high grade resins as the tanks. A complete selection of inlet and outlet adapters permit connection to any piping material, inlet and outlet will be installed at prices indicated below and in positions shown in drawings unless otherwise specified. Prices for inlets and outlets are in addition to tank price.

Inexpensive limestone or marble chunks are used in the neutralization tanks. Successful neutralization involves the resolution of many

# ilution Tanks

factors, including flow rate, volume, composition and temperature of effluent, amount of time exposed to limestone, surface area of limestone.

If burial is necessary, it should be done according to instructions from project engineers or architects.

Neutralization tank extensions are available. Call our Sales Department for prices and specifications.

NOTE: Since effective neutralization is a complex process. Nalge Company recommends the employment of professional assistance to analyze the effluent, recommend appropriate equipment and prescribe necessary maintenance services before ordering neutralization tanks.

# 97000 Black Conventional Polyethylene Neutralization and Dilution Tanks

• Continuous service to 140°F; intermittent to 180°F

Eleven different sizes—5 to 1200 gallons

- Open-top design with heavy-gauge bolt-down cover, neoprete gasket and stainless steel nuts, bolts and washers turnished
- 1200 gallon tank furnished with steel-banded wooden girdle for extra strength.
- Inlets and outlets are priced separately (See chart below)

Size Code	-8005	-0015	-0030	-0055	-0100	-0150	-0200	-0250	-0350	-0500	-1200
Cap., gal.	5	15	30	55	100	150	200	250	350	500	1200
Dimension & in.	16	15	27	33	42	46	45	44	46	60	84
Dimension 8, in.	10	18	18	22	28	31	36	42	48	52	69
Dimension C. in.		10	22	27	36	38	38	36	38	52	72
Dimension D, in.	2	2	3	3	4	6	6	6	6	6	8
Apprex. wall				:	ı						_
thickness, in.	粘	X.	**	; <b>%</b>	' <b>%</b>	<b>1</b> /4	<b>7</b> 4	<b>1</b> /4	<b>%</b>	*	36
Usable volume,		-			!				•		•
cu. ft.	0.58	1.33	3.06	- 5.34	12.00	15.97	20.83	26.51	36.52	61.05	149.24
Max, intel &											
outlet, in.	2	3	3	4/	4	4	6	6	6	6	6
97000 Tanks.				/						•	_
0-1	F11F 00		2100 00	P777 AA	P221 AA	2447.00	F 467 66	PCD3 AA	#777 AA	-1 1	

Price, each** \$116.00 \$164.00 \$186.00 \$233.00 \$331.00 \$447.00 \$497.00 \$683.00 \$737.00 \$1323.00 \$3494.00
**Price includes tank, cover, nuts, balts and gasket only. Inlets and outlets are priced separately below.

#### 97100 Black Linear Polyethylene Neutralization and Dilution Tanks

- Continuous service to 180°F; intermitent to 212°F
- Closed-top design with cover, gasket and stainless steel V-band
- Three sizes—55, 100 and 250 callon
- Excellent chemical, impact and abrasion resistance

Size Code	-0055	-0100	-0250
Cap., gal.	55	100	250
Dimension A, in.	37	46	50
Dimension B. in.	22	28	42
Dimension C. in.	27	36	36
Dimension D. in.	3	4	6
Dimension E. in.	18	18	18
Approx. wall thickness, in.	*	X	×
Usable volume, cu. ft.	5.0	11.5	25.0
Max, inlet & outlet, in.	4	4	6
97100 Tanks, Price, each*	\$136.00	\$162.00	\$243.00

*Price includes tank, cover and V-band only, inlets and outlets are priced separately below.

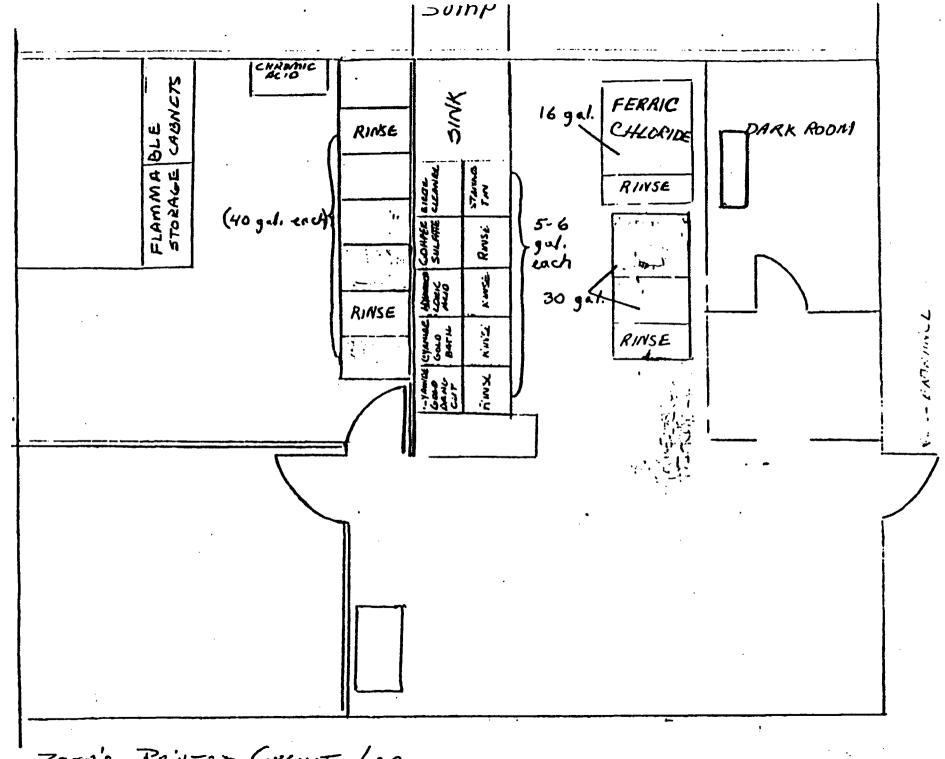
# Inlets and Outlets

To determine the total price of the complete neutralization tank, add the price of each inlet and outlet required to the price of the tank. Inlet

includes connecting adapter, elbows and dip pipe. If a vent is required, order any outlet listed in the chart.

Pipe connections consist of plain nipple and installed half coupling for field assembly.

					-			•			-						
	Pipe			drilled to	NPT Semale threads to male IPS threads			Mechanical joint to hi-silicon iron pipe			Plain end pipe connections 12" long			NPT threads			
Size	Size, in.	96401 Inlet	F° in.	93400 Outlet	99840 Inlet	ř٠ in.	93840 Outlet	96804 Inlet	F* in.	96800 Outlet	\$2800 inlet	f" in.	92801 Outlet	96857 Inlet	F*	93857 Outlet	
J150 -0200 -0300 -0400 -0500	1½ 2 3 4 6	\$58.00 78.00 114.00 135.00 191.00	4% 4% 4% 6% 6%	\$53.00 67.00 75.00 87.00 98.00	\$40.00 48.00 74.00 95.00	13% 13% 23% 23%	\$30.00 36.00 64.00 80.00	\$43.00 \$4.00 80.00 101.00	1½ 1½ 2½ 2½	\$33.00 43.00 67.00 87.00	\$34.00 42.00 67.00 83.00 104.00	136 136 276 276	\$19.00 20.00 23.00 29.00 75.00	\$39.00 46.00 74.00 91.00	2% 2% 2% 2%	\$22.00 23.00 25.00 31.00	



ZETA'S PRINTED CIRCUIT LOB

# Certified Engineering & Testing CompanyTM

Boston · Providence · New York · Memphis · Dallas · San Francisco

PHASE I ENVIRONMENTAL SITE ASSESSMENT

SAN TOMAS BUSINESS PARK SCOTT & MONTGOMERY SANTA CLARA, CALIFORNIA

PREPARED FOR:
MS. SHARON POSNER
PROPERTY MANAGER
ESSEX PROPERTIES CORPORATION
777 CALIFORNIA AVENUE
PALO ALTO, CALIFORNIA 94304

CERTIFIED PROJECT NO: S90049
MARCH 22, 1989

PREPARED BY:

JOSE A. NAVARRO PROJECT COORDINATOR

REVIEWED BY:

CHRISTOPHER M. FRENCH, R.G., R.E.A.

REGISTERED GEOLOGIST #4465 (EXP. 6/30/90)

REGISTERED ENVIRONMENTAL ASSESSOR #00308 (EXP. 6/30/89)

REVIEWED BY:

MARC D. CUNNINGHAM GENERAL MANAGER

Certified Engineering & Testing Company, Inc.



# Certified Engineering & Testing Company™



Boston · Providence · New York · Memphis · Dallas · San Francisco

March 22, 1989

Ms. Sharon Posner
Property Manager
Essex Property Corporation
777 California Avenue
Palo Alto, California, 94304

Subject: Environmental Site Assessment for Potentially Hazardous Materials at the San Tomas Business Park, Santa Clara,

California.

Dear Ms. Posner:

This letter is to inform you that Certified Engineering & Testing Company's Site Assessment for the above referenced property is complete. Our findings and recommendations are herein stated.

Certified Engineering's environmental site assessment of the San Tomas Business Park, an investigation and inquiry consistent with good commercial real estate practices, indicated that trace soil and ground water contamination is present.

Certified's subsurface investigation found that groundwater contamination is present as a result of an off-site spill approximately 1,000 feet to the south of the subject site. The spill is presently being remediated by Synertek Corporation.

A former on-site waste water storage tank appears not to have impacted the quality of soils on-site.

Gas cylinders located in Building One were found to be properly labeled, secured from falling, and stored on a concrete floor.

The electrical transformers found on-site are PCB free.

There are EPA Superfund and NPL sites within a 2,000 foot radius of the site. Additionally, there are California Department of Health Services Expenditure Plan Sites within the same radius.

For further details, please refer to the enclosed reports.

If you have any questrons concerning the report, please feel free to call me.

Sincerely,

CERTIFIED ENGINEERING & TESTING COMPANY, Inc.

Cost. Mount

Jose A. Navarro Project Coordinator

JAN/cw

enc.



# Certified Engineering & Testing Company™

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# Certified Engineering & Testing CompanyTM



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# I. INTRODUCTION

Certified Engineering & Testing Company, Inc. was retained by Ms. Sharon Posner of Essex Properties Corporation of Palo Alto, California, to perform a Phase I Environmental Site Assessment for the San Tomas Business Park at the intersection of Scott Boulevard and Montgomery Drive in Santa Clara, California (See Figure 1-2, Appendix A, and Photographs 1-4, Appendix B).

The Phase I Site Investigation consisted of visual inspections of the grounds of the subject site and of abutting properties. In addition to interviews with on-site personnel, Certified undertook background research at the City of Santa Clara, the Santa Clara County Offices, the California Department of Health Services and the U.S. Environmental Protection Agency. A complete listing of information sources is presented on pages 19 to 21.

The visual inspection of the site was performed on February 9, 1989 by Jose A. Navarro of Certified, who assessed the site for naturally occurring environmental hazards and toxic site contamination potentially resulting from the release of hazardous substances to the buildings, soils and groundwater.

This report discusses both on and off-site envi. mental concerns. The potential on-site concerns may include: 1) hazardous materials storage or potential soil/groundwater contamination; 2) underground storage tanks (USTs); and 3) electrical transformers containing polychlorinated biphenyls (PCBs).

The potential off-site concerns may include: 1) nearby leaking underground storage tanks (USTs); 2) nearby facilities that store hazardous waste; 3) nearby spills, dumps, landfills of hazardous materials which may impact the subject site; and 4) migration onto the site of groundwater arising from an upgradient source.

#### II. SITE DESCRIPTION

The assessed site, consisting of approximately 5 acres (220,000 square feet) on flat alluvial soils, is located on the western city limits of Santa Clara, California. The site is bounded by Augustine Drive to the north, Montgomery Drive to the east and Scott Boulevard to the south. The western property boundary borders a single story office/light industrial building.

According to the National Flood Insurance Program, the subject site is with the 100 year flood zone of San Tomas Creek, which is located 1,400 feet east of the site. The groundwater table beneath the site is shallow. The water depth may vary slightly due to seasonal changes.

Seismically active fa ts near the site include e San Andreas Fault, approximately 18 miles to the west of the site. This fault system is active, affecting both the Santa Clara Valley and the San Francisco Bay Area. Soils underlying the site consist of unconsolidated alluvial deposits including clay, silt, sand and gravel.

The three, single-story concrete tilt-up frame structures were constructed in 1976. The square footage of Buildings One and Three, located on the northern and southern property boundaries respectively are both approximately 30,300 square feet, while the middle structure, Building Two is approximately 16,100 square feet.

Building One is divided into three spaces. Property addresses at this building are 2600 Augustine Drive, 3370 and 3380 Montgomery Drive. Both the Montgomery Drive addresses are presently occupied by Magnum Technology Corporation and White Hawk Laser, respectively. The 2600 Augustine Drive address is presently vacant.

Building Two is divided into three spaces. The Duplicators occupies the 3340 Montgomery Drive address while both the 3350 and 3360 Montgomery Drive spaces are vacant.

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Building Three is provently divided into two spaces. Both areas are occupied by Ultracision, located at 3310 Montgomery Drive, and Cyress Electronics, located at 3265 Scott Boulevard.

Prior to the buildings construction, the former land-use of the site and surrounding lands was agricultural, probably for the cultivation of citrus fruits. Present land-use within a 2,000 foot radius of the subject site is dominated by light industrial and office buildings with some commercial uses to the northwest.

# III. SITE INVESTIGATION

On-Site Investigation:

The site investigation and subsequent record search focuses on environmental concerns related to: 1) hazardous materials on site; 2) the handling, disposal, manufacture and transportation of such materials; 3) PCB-containing vessels; and 4) radon.

Jose A. Navarro inspected the buildings, including those areas where potential hazardous materials might have been located.

According to the City of Santa Clara's "Hazardous Materials

Inventory Summary' dated March 9, 1988, Planar Microwave, a

manufacturer of electronic components and the former occupant of

2600 Augustine Drive in Building One, stored a limited amount of

hazardous materials. Freon 113 and waste product of ammonium hydroxide, copper, phenol, sulfuric acid and liquid trichlorobenzene were handled at this site. As much as 150 gallons of Freon 113 were used by Planar Microwave within a year at this site.

During the visual inspection of this space, no evidence of chemical spills was found at the Planar Microwave address.

A hazardous materials closure inspection was conducted on January 25, 1989 by SPM Applied Environmental along with the Santa Clara Fire Department's hazardous materials specialist, Dave Parker. According to the February 15, 1989 report, no evidence of any illegal dumping of hazardous materials was found at the Planar Microwave address.

No record(s) of any spill incidences or tank leaks existed in file for the San Tomas Business Park with the Santa Clara Fire Department.

Located at 3380 Montgomery Drive in the space occupied by White Hawk Laser, Inc., in Building One, were approximately 50 cylinders of compressed gasses. Cylinder contents varied from argon, carbon dioxide, nitrogen, oxygen to helium. According to the 'Hazardous Materials Inventory Statement' dated September 30,

1988 the above mentic d gases have been registe d for storage at their 3380 Montgomery Drive address. These gases are not considered to be hazardous materials and because they are non-flammable, non-corrosive and have a low toxicity, they are able to be stored together as they are seen in photographs 6-8, Appendix B.

All full compressed gas cylinders in service or in storage were found to be properly labeled, secured by a chain to prevent falling or being knocked over, and stored on a concrete floor.

Also found in Building One, in the Magnum Tech Co. occupied space was a small empty cylinder of nitrogen stored with a fire extinguisher. This cylinder was also properly stored (please see Photograph 5, Appendix B). There was no evidence or records of any storage of hazardous materials at this site.

No evidence of any hazardous materials was found in the vacant space formerly occupied by Healthco and in the space presently occupied by The Duplicators in Building Two.

During the site investigation of Building Three, no hazardous materials were found in the Ultracision occupied space at 3310 Montgomery Drive.

The City of Santa Cla 's tank removal files ind ate the historical presence of a 55 gallon waste water storage tank in an underground vault located in the Building Three area.

Installation of the tank took place in 1979 by Zeta Laboratories, the former occupant of 3265 Scott Boulevard. The tank was used for the storage of waste rinse water from the plating process in semiconductor production. The tank was removed on October 10, 1986.

Inspection of the tank during removal showed the tank to be in good condition. Soil sample analysis taken from the tank area indicated no signs of contamination.

Certified's aerial photography research revealed the presence of seven above-ground storage tanks in the loading dock area of Building Three. The white tanks were fenced in at the time and can be seen in the 1987 photograph taken by the City of Santa Clara (See Figure Two, Appendix B). Research conducted through City and County governmental agencies did not disclose any information as to the use and contents of these tanks. Permits for the installation and removal were not found with the City of Santa Clara Fire Department. During the site investigation, no apparent stains or discolorization were found in the area (See Photograph 11, Appendix B).

Storage of 20 gallons f paint thinner was found n the Cypress Electronics space in Building Three. The gallon size containers are stored in two separate cabinets, with each containing miscellaneous materials such as bleach and spray paints (See Photographs 9-10, Appendix B).

Outgassing of radon has not been a problem in the Santa Clara area, thus no testing was conducted.

Off-Site Investigation:

Certified investigated potential environmental problems in the nearby vicinity that could impact the subject site. Research was conducted for the potential existence of any nearby leaking underground storage tanks, contaminated sites, spills and landfills/dumps within 2,000 feet of the subject property. Formal requests for information were given and interviews conducted with personnel of the City of Santa Clara, the Santa Clara Fire Department, the Santa Clara Engineering Department, the U.S. Environmental Protection Agency and the California Department of Health Services. A complete list of information sources is found on pages 19-21 of this report.

Reports furnished by the California Department of Health
Services, the Office of Planning and Research and the U.S.
Environmental Protection Agency disclosed the presence of
hazardous waste sites within two thousand feet of the property.

Certified's record search disclosed nine contaminated off-site concerns with leaking underground storage tanks and/or contaminated soils and groundwater located within a 2,000 foot radius of the subject site (See Figure 3, Appendix A).

An off-site concern affecting the San Tomas Business Park is the Synertek, Bldg. #1, located at 3050 Coronado Drive in Santa Clara (See Figure 3, Appendix A). This site is located approximately 1,000 ft. south of the subject site.

Contamination at the Synertek property originated from several onsite leaking underground storage tanks which were removed along
with contaminated soils in 1985. Contaminants such as
trichloroethylene (TCE), 1,1,1-trichloroethane (TCA), 1,1dichloroethane (DCA), 1,1-dichloroethylene (DCE), Trans-1,2dichloroethylene (TDCE), Freon 113 and Vinyl Chloride have
polluted the ground waters beneath this site. Contamination is
present in both soil and groundwater, and groundwater
contaminants have migrated off-site towards the northeast, in the
direction of the groundwater gradient flow.

Groundwater monitoring data indicates that the plume has extended vertically to a depth of 45 feet and horizontally a distance of at least 1,500 feet in aquifer "A", located 20 feet below the ground surface. (See Figure 4, Appendix A).

As can be seen in F are 4, the extent of the intaminated plume's western edge has migrated to the subject site's southeastern boundary. In order to cleanup and prevent the further spread of polluted ground waters from the off-site concern, Synertek has installed several extraction wells to remove polluted waters from this plume, causing the plume to recede. Groundwater extraction has been conducted under the supervision of the Regional Water Quality Control Board.

Contamination to aquifer "B", located approximately 15-20 feet below aquifer "A" has also resulted in a polluted groundwater plume. Test results have shown that this plume has been restricted to the Synertek property due to flow restrictions from compacted soils. This plume does not appear to have impacted the San Tomas Business Park.

Research conducted reveals that soil and groundwater contamination from the remaining eight sites is either of localized extent, or may not impact the subject site given: 1) the distance between the subject site and the contamination source or 2) soil and groundwater remediation measures undertaken for environmental abatement.

# IV. CONCLUSIONS AN! RECOMMENDATIONS

Certified Engineering's environmental site assessment of the San Tomas Business Park, an investigation and inquiry consistent with good commercial practice, indicated that hazardous materials have been stored and used on the subject site.

There is evidence suggesting that groundwater contamination may be present as a result of off site activities. An on-site wastewater storage tank appears to have impacted the quality of soil on site, based on limited information furnished to Certified.

Results of background research disclosed a possible on-site and one off-site concern which may affect the subject site. The on-site concern is the historical use and storage of seven unidentified above-ground storage tanks in the loading dock area of Building Three, and the former presence of the aforementioned wastewater tank. The off-site concern is ground water contamination associated with the Synertek Building #1, located approximately 1,000 feet south of the subject site.

Certified recommends a subsurface investigation for the San Tomas Business Park to ascertain possible contamination from the aboveground storage tanks and the Synertek site. Soil and water chemical analysis sland be consistent with idacification of common electronic industry solvents. Samples should be analyzed for evidence of organic solvents such as Freon, trichloroethylene, trichloroethane and other organic solvents as previously mentioned in the "Off-Site Investigation" section of this report.

There are no known storage tanks (underground/above-ground) currently on the the subject property.

All gas cylinders stored in Building One were found to be properly labeled, stored on a concrete floor and secured by a chain to prevent falling or being knocked over.

All paint thinner containers noted in Building Three were stored correctly and away from any potentially flammable materials. Certified recommends that all paint thinner containers be stored in a single fire proof flammable liquid storage cabinet. There was no indication of leaks or spills and materials were labeled properly.

Electrical transformers installed by Pacific Gas & Electricity onsite do not contain polychlorinated biphenyls (PCBs). Radon was not tested for because it is not a recognized environmental problem in the Santa Clara area.

Certified Engineering can assist the building owner on the implementation of our recommendations.

## V. FIELD FORMS

# Site History

A. Owner of property:

Rosenberg Real Estate
Equity Fund II, Inc.,
A Delaware Corporation
by RREEF Management Co.
A California Corp.
155A Moffett Park Dr., #110
Sunnyvale, California, 94089

B. Type & Date of Construction of the Buildings:

Three, single-story concrete tilt-up frame structures constructed in 1976.

C. Total Acreage and Square Footage of the Buildings:

Site: 5.00 acres (220,000 square feet)
Building One: 30,300 square feet.
Building Two: 16,100 square feet.
Building Three: 30,300 square feet.

- D. Zoning:
  - i. Present Classification and dates: X Industrial Commercial Agricultural Residential Other
  - ii. Prior Classification:

The prior zoning classification was agricultural.

E. Current Uses:

The current use of the subject site is used for office space and light industrial uses.

F. Former Uses of Site:

The site was formerly an agricultural field, used for the production of citrus trees.

G. List of B ironmental Permits Held k Current and Former Site Owners:

No environmental permits are held by the current and former site owners.

H. Current and Former Uses of Surrounding Properties:

The surrounding land is currently used for office and light industrial purposes.

I. Summary of Prior Citations or Fines for Violations of Environmental Regulations:

No prior citations or fines exist for the subject property.

J. Major Findings/Background Research (including any limitations thereto):

Potential off-site contamination migration to subject site and historical storage of hazardous materials by former building occupant at 2600 Augustine Drive. Unidentified above-ground storage tanks formerly located in loading dock area of Building Three.

K. Recommendations, if any, for Field Investigation (Phase II):

Subsurface investigation to ascertain possible contamination from the Synertek bldg. #1, located at 3050 Coronado Drive in Santa Clara and possible on-site contamination.

2. Physical Charact istics of Subject Site

#### TOPOGRAPHY

The topography is a flat-lying terrain.

# SOILS

Soils consist of unconsolidated, course grained sands and gravels, interbedded with finer grained silts and clays.

#### VEGETATION

Vegetation on-site consists of ornamental vegetation.

# WETLANDS

No wetlands exist on site.

#### SURFACE WATER

No surface water was observed on-site.

# ESTIMATED DEPTH TO GROUNDWATER

The estimated depth to groundwater is 15-20 feet.

# 3. DESCRIPTION OF SUBJECT SITE

#### WELLS

No wells exist on-site.

# SANITARY SEWERS SYSTEM

The sanitary sewer system is under the jurisdiction of the property owner.

#### LAGOONS OR PITS

No lagoons or pits exist on-site.

## **DITCHES**

No ditches currently exist on-site.

# FLOOR DRAINS

No floor drains currently exist on-site.

# DRAINAGE LINL

Typical storm drains are found on the street curbs.

## SUMPS

No sumps exist on-site.

### **EASEMENTS**

No utility easements exist on-site.

# SITE UTILITIES

The site's utilities are served by the City of Santa Clara, the Santa Clara Valley Water District and Pacific Gas & Electricity.

# BUILDINGS, ROADWAYS AND PARKING AREAS

The buildings are bounded by Augustine drive to the north, Montgomery Drive to the east, and Scott Boulevard to the south.

# **FENCING**

No fencing exists on the site.

# 4. Hazardous and Potentially Hazardous Materials and Fuels

# SEPTIC TANKS/LEACHING FIELDS

No septic tanks or leaching fields were known to exist on-site.

## DRUM STORAGE

No drums are stored on the site.

#### ABOVE GROUND/UNDERGROUND TANKS

No above ground/underground storage tanks presently exist at the subject site.

#### HAZARDOUS WASTE DISPOSAL

There was no evidence of hazardous waste disposal on the site.

## BATTERY DISPOS

No batteries were found on the site.

#### WASTE OIL DISPOSAL

There is no waste oil stored on the site.

# LIST OF HAZARDOUS MATERIALS ON-SITE

Approximately 20 gallons of paint thinner were found stored at the 3625 Scott Blvd. address and 50 gas cylinders are stored at the 3380 Montgomery Drive.

# TRANSFORMERS

Two PCB free transformers are found on the subject site, placed by Pacific, Gas & Electricity.

# MAINTENANCE

Maintenance is provided by the property manager.

- 1. Persons/Offices Contacted Regarding the Site:
  - -Dave Parker, Ph.D., Hazardous Materials Adminsitrator, Santa Clara Fire Dept., 777 Benton St., Santa Clara, Ca., 95050, (408) 984-3084.
  - -Robert J. Campbell, Chemcial Specialist, Santa Clara Fire Dept. 777 Benton St., Santa Clara, Ca., 95050, (408) 984-3084.
  - -<u>Ida Tolliver</u>, Environmental Protection Agency, 215 Fremont St. San Francisco, CA., 94105.
  - -Doris Cruz, Custodian of Records, Department of Health Services Toxic Substances Control Division, 5850 Shellmound St., Emeryville, Ca., 94608.
  - -Tom Iwamura, Geologist, Santa Clara Valley Water District, (408) 277-5297.
  - -Santa Clara County Health Dept., Hazardous Materials Unit, 2220 Moorpark Ave., San Jose, Ca., 95128, (408) 299-6930.
  - -Santa Clara Planning Agency, 1500 Warburton Ave., Santa Clara, Ca., 95050, (408) 984-3111.
  - -Santa Clara County Assessors Office, (408) 299-3227.
  - -Santa Clara Valley Water District, (408) 265-2600.
  - -Regional Water quality Control Board, Region 2, Bay Area, 1111 Jackson St., Oakland, Ca.
- 2. Reports, Plans or Other Documents Reviewed:
  - -Leaking Underground Storage Tanks and Toxic Sites, California Department of Health Services, 5850 Shellmound Street, Emeryville, California.
  - -<u>"Applied Action Levels"</u>, California Department of Health Services, Toxic Substance Control Division, 5850 Shellmound Street, Emeryville, California.
  - -Expenditure Plan for the Hazardous Substance Cleanup Bond Act of 1984, (Revised January 1988). California Department Of Health Services, 5850 Shellmound Street, Emeryville, California, (415)540-3500.

-U.S. Environm Ial Protection Agency Sup Fund Program, CERCLIS, CERCLIS Database. EPA, 215 Fremont Street, San Francisco, CA. 94105.

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- -Underground Storage Tanks Fuel Leaks, Regional Water Quality Control Board Region 2 (Bay Area), 1111 Jackson Street, Oakland, CA., 94607.
- -<u>Hazardous Waste and Substance Sites List</u>, California Office of Planning and Research, 1400 Tenth Street, Sacramento, CA., 95814.
- -Toxic Sites, prepared by Fox & Carskadon Commercial Services, Inc., 2099 Gateway Place, Suite 550, San Jose, Ca., 95110 for Mr. Ross J. Boyert, Vice President, Essex Property Corp., 777 California Ave., Palo Alto, Ca., 94304, February 8, 1989.
- -Hazardous Materials Closure for Planar Microwave, prepared by SPM Applied Environmental for Sherie Dunn, The RREEF Funds, 155A Moffett Park Drive, Suite 110, Sunnyvale, Ca., 94089, February 15, 1989.
- -Synertek Building #1, Progress Report, February 1988, prepared by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408.
- -Applied Materials Groundwater Cleanup Program, Regional Water Quality Control Board Internal Memo, from Robert W. Marek, Water resources Control Engineer to Richard K. McMurtry, File No. 2189.8152, May 27, 1988.
- -Quarterly Ground Water Monitoring Report, WA Job #1-169-01, by Weiss Associates, 2938 McClure St., Oakland, Ca., 94609, for Jerry Schoening, Applied Materials, 3050 Bowers Ave., Santa Clara, Ca., 95051, October 5, 1988.
- -Synertek Building #1, Progress Report, May 1988, prepared by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408.
- -Performance Assessment of "B" Aguifer Extraction Well PW-3, Synertek Building #1, by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408, March 9, 1988

- -Evaluation of Interim On-Site Hydraulic Intainment and Soil Removal Measures and Modifications, Synertek Building #1, by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408, September 8, 1987.
- -Evaluation of Interim On-Site Hydraulic Containment and Soil Removal Measures and Modifications, Synertek Building #3, by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408, September 8, 1987.
- -Plume Definition Report & Off Site Remedial Plan, Synertek #1, by Conestoga-Rovers & Associates Limited, 651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2, (512) 884-0510 for Mr. Ken Ford, Honeywell Inc., Honeywell Plaza, 2701 4th Ave. S., Minneapolis, Mn., 55408, February 1988.
- -Quarterly Monitoring Report for Magnitics Peripherals, Inc, Santa Clara, Ca., Extraction and Treatment System Data for July-September, 1988, prepared by Levine-Friche (LF 1085), 1900 Powell St., 12th floor, Emeryville, Ca., 94608,652-4500, October 31, 1988.
- -Aerial Photograph, Santa Clara Planning Agency, 1500 Warburton Ave., Santa Clara, Ca., 95050, (408) 984-3111.
- -Milpitas, Ca., Topographic Map, 1961, Photorevised 1980, U.S. Geological Survey, Denver, Co., 80225.

### VII. LIMITATIONS & SERVICE CONSTRAINTS

# LIMITATIONS

The findings set forth in the attached Site Assessment Report are strictly limited in time and scope to the date of the evaluation(s). The conclusions presented in the Report are based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of agreed upon services or the time and budgeting restraints imposed by the client.

This report may contain recommendations which are partially based on the analysis of data accumulated at the time and place set forth in the report through subsurface exploration. However, further investigations may reveal additional data or variations of the current data which may require the enclosed recommendations to be reevaluated.

Chemical analyses may have been performed for specific parameters during the course of this site assessment, as described in the text. However, it should be noted that additional chemical constituents not searched for during the current study may be present in soil and/or groundwater at the site.

Partial findings of this investigation are based on data provided by others. No warranty is expressed or implied with the usage of such data.

#### SERVICE CONSTRAINTS

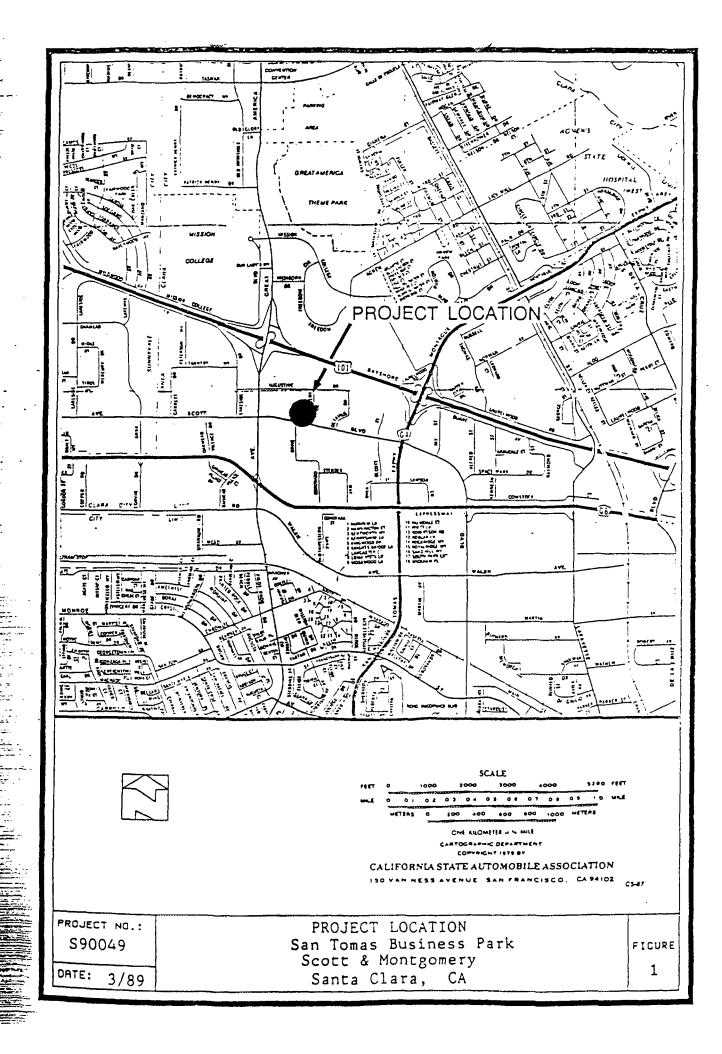
Much of the information provided in this report is based upon personal interviews and research of all available documents, records and maps held by the appropriate government and private agencies. This is subject to the limitations of historical documentation, availability and accuracy of pertinent records and the personal recollection of those persons contacted.

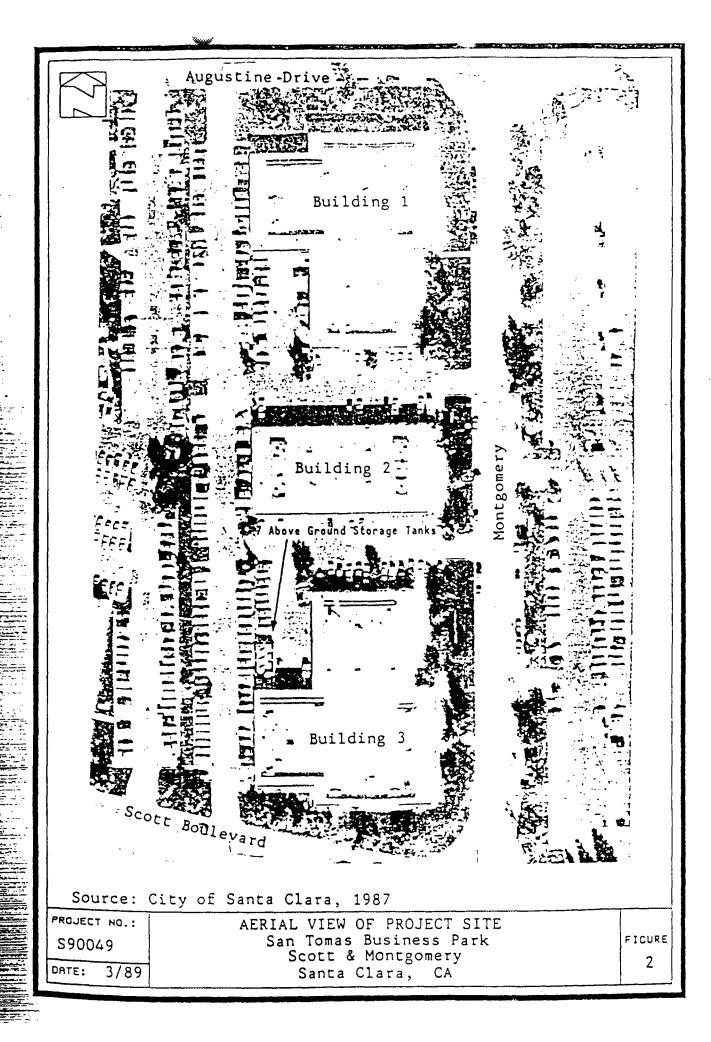
The initial site investigation took into account the natural and manmade features of the site, including any unusual or suspect phenomenon. These factors, combined with the site's geology, hydrology, topography and past/present land uses served as a basis for choosing a methodology and location for subsurface exploration as well as groundwater and subsurface sampling, if done. The subsurface data, if provided, is meant as a representative overview of the site.

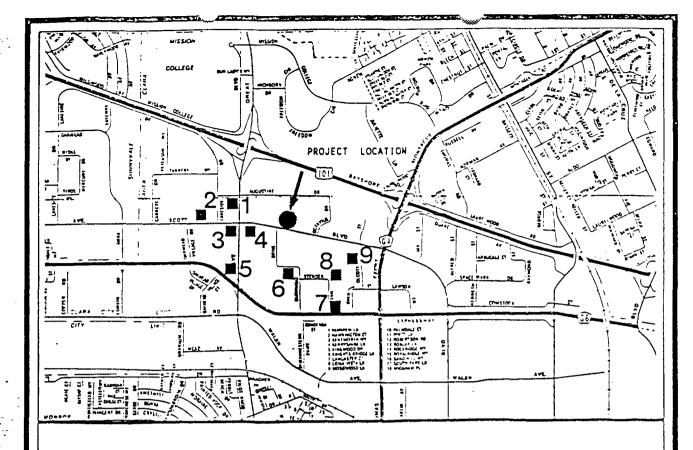
The location and analyses of soils, groundwater and surface water samples, if provided, was based on the same considerations listed in the paragraphs above. If samples were analyzed, they were analyzed for those parameter unique to the site as determined from the preceding site evaluation.

The presence of radioactive materials, biological hazards and asbestos was not investigated unless specifically noted otherwise.

This report is intended for the use listed in the section of this report described as the Introduction or Scope of Work. The use of this report in any other manner than that listed in the Introduction for Scope of Work requires the written consent of Certified Engineering and Testing Co., Inc. This report must be presented in its entirety.

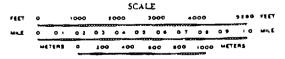






- 1. SHELL SERVICE STATION Bowers & Augustine
  - 2. MAGNETIC PERIPHERALS, INC. 3333 Scott Boulevard
  - 3. HEWLETT PACKARD & SPERRY UNIVAC 3300 Scott Boulevard
  - 4. AVANTEK, INC. 3175 Bowers Avenue
  - 5. APPLIED MATERIALS 3050 Bowers Avenue
  - 6. SYNERTEK, BUILDING 1 3050 Coronado Drive
  - 7. SPECTRA PHYSICS, INC. 2905 Stender Way
  - 8. SYNERTEK, BUILDING 3 3001 Stender Way
  - 9. NBK 30101 Olcott Street





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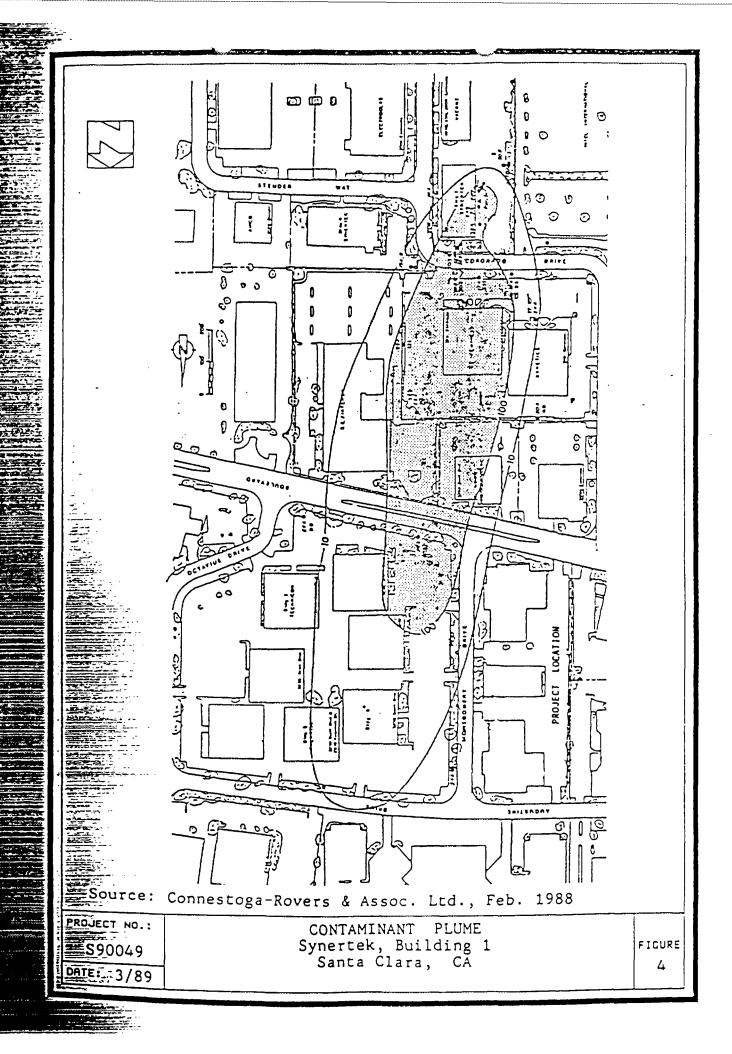
CALIFORNIA STATE AUTOMOBILE ASSOCIATION 150 VAN NESS AVENUE SAN FRANCISCO, CA 94102

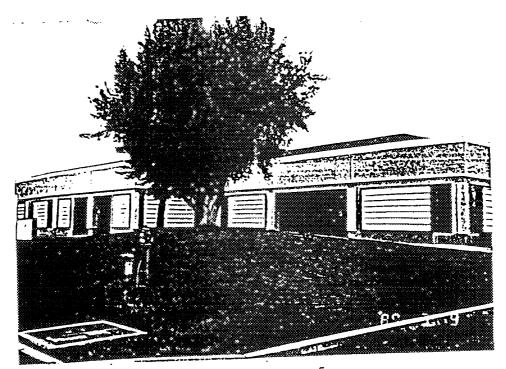
PROJECT NO .: S90049 DATE: 3/89

OFFSITE CONCERNS San Tomas Business Park Scott & Montgomery Santa Clara, CA

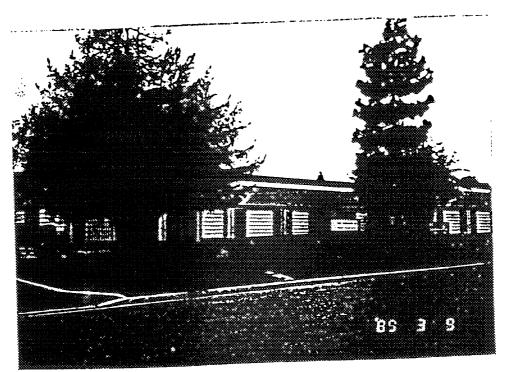
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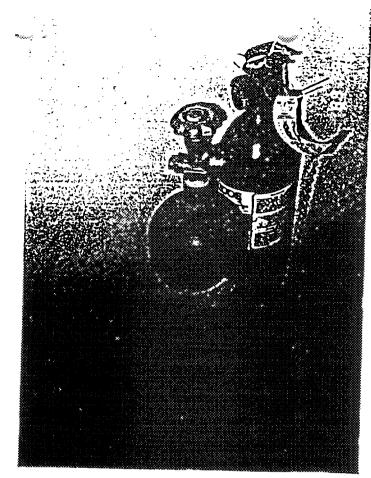




Photograph #1: View of Building one from Augustine Drive.

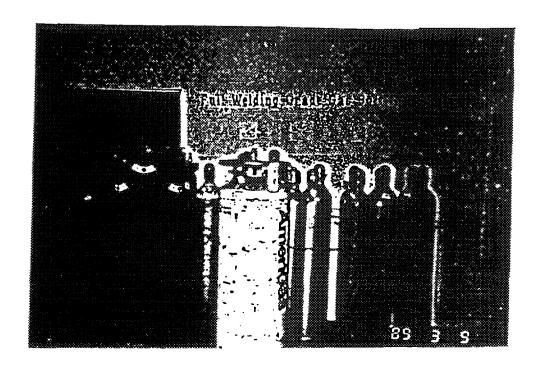


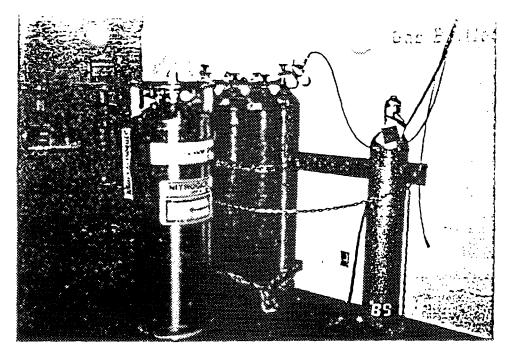
Photograph #2: View of Building One from Montgomery Drive



Photograph #5: Empty hydrogen gas cyliner stored at 3370 Montgomery Drive.

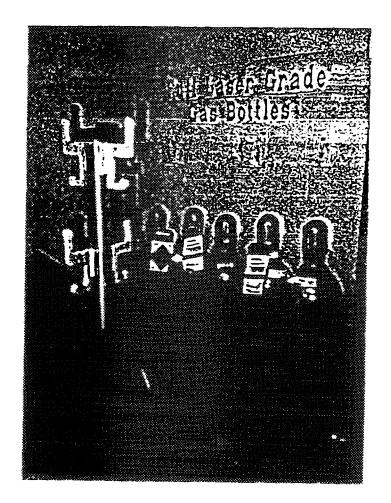
Photograph #6: Gas cyliners of Carbon Dioxide, Nitrogen and Oxygen.

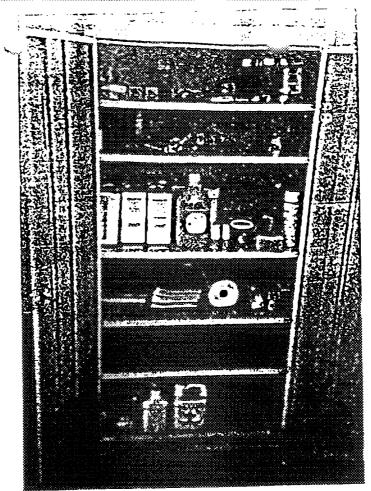




Photograph #7: Gas cylinders of nicrogen and oxygen at 3380 Montgomery Drive.

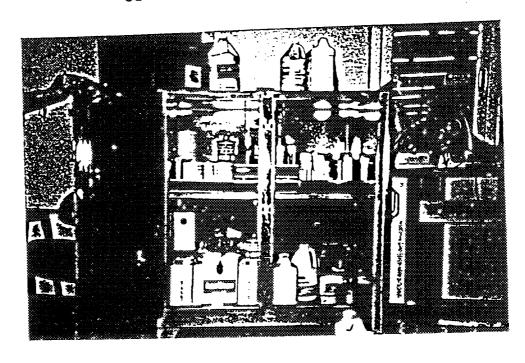
Photograph #8: Storage of Helium and Carbon dioxide at 3380 Montgomery Drive.

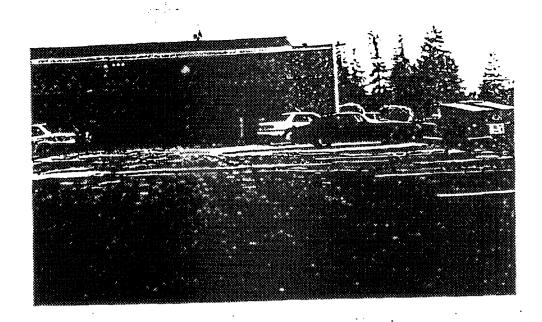




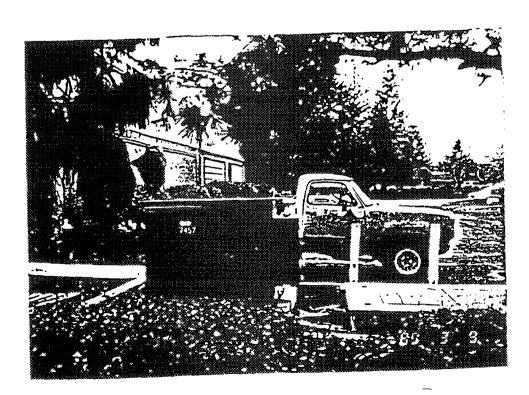
Photograph #9: Storage of paint thinners located at 3265 scott Blvd.

Photograph #10: Storage of paint thinners in fire proof flammable liquid storage cabinet at 3265 Scott Blvd.





Photograph #11: former storage area of seven above-ground scorage tanks.



Photograph #12: PCB free transformer located near Building One.



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PHASE II
ENVIRONMENTAL SITE ASSESSMENT

SAN TOMAS BUSINESS PARK SCOTT & MONTGOMERY SANTA CLARA, CALIFORNIA

PREPARED FOR:
MS. SHARON POSNER
PROPERTY MANAGER
ESSEX PROPERTIES CORPORATION
777 CALIFORNIA AVENUE
PALO ALTO, CALIFORNIA 94304

CERTIFIED PROJECT NO: S90049
MARCH 22, 1989

PREPARED BY: Inn OFFice

TIM O'BRIEN STAFF GEOLOGIST

REVIEWED BY:

CHRISTOPHER M. FRENCH, R.G., R.E.A.

REGISTERED GEOLOGIST #4465 (EXP. 6/30/90)

REGISTERED ENVIRONMENTAL ASSESSOR #00308 (EXP. 6/30/89)

REVIEWED BY:

MARC D. CUNNINGHAM GENERAL MANAGER

Certified Engineering & Testing Company, Inc.
725 Greenwich Street, Suite 204, San Francisco, CA 94133 (415) 986-6872 - TeleFAX (415) 986-4283



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### I. INTRODUCTION

This report describes the subsurface investigation performed by Certified Engineering and Testing Company (Certified) at the San Tomas Business Park located along Montgomery Drive in Santa Clara, California. The investigation was performed on March 13 and 14, 1989. Please see Figure 1, Appendix A for the site location.

This investigation was authorized by Ms. Sharon Posner of the Essex Property Corporation.

The scope of our services included:

- -- An underground utility search;
- -- Drilling three soil borings of sufficient depth to construct ground water monitoring wells;
- -- Conversion of soil borings to ground water monitoring wells;
- -- Well development and sampling; and
- -- Interpretation of laboratory results and report preparation.

### II. SITE DESCRIPTION

For background information on this property, please refer to the site description provided in the Phase I Environmental Site Assessment by Certified dated March 22, 1989. To summarize the findings:

- -- A contamination plume consisting of organic solvents originating approximately 1,000 feet south of the subject site may be affecting the subject site.
- -- Hazardous materials have been stored on the site, including Freon.

#### SUBSURFACE GEOLOGY AND HYDROLOGY

The site is underlain by alluvium, deposited by the action of streams flowing into San Francisco Bay. The alluvial deposits and interbedded bay mud deposits of the ancestral San Francisco Bay are estimated to be over 1,000 feet thick. The near surface soils consist primarily of clayey soils of generally low permeability.

The low permeability deposits do not readily transmit water. However, the clayey soils are locally interbedded with layers of sand and gravelly sand, deposited by ancestral stream deposits. The higher permeability of sandy lenses encountered beneath the site allows for more rapid ground water transport.

### III. FIELD INVESTIGATION

Prior to drilling, the borehole locations were cleared for underground utilities by informing Underground Service Alert. Underground service alert notifies companies in the area which maintain underground utilities.

Well construction permits were issued by the Santa Clara Valley Water District.

#### SOIL BORINGS

On March 13 and 14, 1989, three soil borings were drilled to a depth of 25 feet. The boring locations are shown on Figure 2, Appendix A. One boring was located near a storage area noted on an air photo; the two other boring locations were chosen to give as complete coverage of the business park as possible. The borings were advanced with a CME 75 truck mounted drill rig using an 8-inch diameter, continuous flight, hollow-stem auger. Prior to drilling each boring, the augers and sample equipment were steam cleaned to prevent cross contamination.

Native soil consisting of hard clays was encountered in all of the borings. Silty sand and sand was encountered in Boring #1 at approximately 13 to 24 feet. No backfill was encountered in any of the borings.

Certified's geologist supervised the drilling operations, logged the borings, and collected soil samples. After drilling through the asphalt, the possible existence of underground utilities was determined using a hand auger. After verifying the area to be free of underground utilities, drilling proceeded.

Soil samples were collected at five foot intervals using a 2.5-inch diameter California Modified split spoon sampler lined with brass sleeves. The sampler was driven 18 inches with a standard 140-pound hammer repeatedly dropped 30 inches. The blow count required to drive the sampler each 6 inches was recorded in order to determine the relative consistency of the soils.

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During sampling, soil cuttings from the boreholes were analyzed with an H*NU photoionization detector which is capable of measuring organic vapors. The instrument can detect the presence of organic vapors to the part per million level. No organic vapors from the soil cuttings were detected.

Soil samples were sealed using aluminum foil, plastic end caps, and duct tape. The samples were immediately placed on ice awaiting transportation to a state certified laboratory under proper chain of custody protocol. The Chain of Custody Record is included in the Appendix B.

Soils encountered in the boring were classified in accordance with the Unified Soil Classification System, as described in Figure 3, Appendix A. Logs of the borings are presented in Appendix C.

All soil cuttings from the borings were stored in DOT approved 55gallon drums. The drums were sealed and bolted shut and stored in the parking area away from traffic.

#### MONITORING WELL CONSTRUCTION

The three soil borings were converted to two-inch diameter wells to allow for evaluation of ground water conditions beneath the site. The wells extend to an approximate depth of 12 feet below the first occurrence of ground water.

The wells were constructed of two-inch (inside diameter), thread jointed, polyvinyl chloride (PVC) casing. No chemical cements, glues, or solvents were used in well construction. The bottom of the casing consists of a threaded end cap; the top of the casing consists of a slip cap. The screened portion of the wells consists of factory perforated 0.020-inch slotted casing. The well screen extends from the total depth of the well to approximately four feet above the upper zone of saturation to allow for monitoring during seasonal fluctuations of ground water levels. The annular space was packed with sorted and washed sand to approximately two feet above the perforations. A one-foot thick bentonite plug was placed above the

sand as a seal against cement entering the sand pack. The remaining annulus was filled with a cement/aggregate/bentonite slurry to approximately one-half foot below grade. The well was completed with a waterproof and tamper-resistant wellhead cover set in concrete slightly above grade.

#### GROUND WATER SAMPLING

The wells were allowed to set up for 24 hours before sampling. A steam cleaned bailer was used to obtain a sample from the surface of the water in each well for subjective evaluation of ground water quality prior to purging. No floating product or sheen was found on the water in any of the wells.

The wells were each purged three well volumes. Water samples were retrieved using a teflon bailer cleaned with Alconox and rinsed with distilled water. The bailer was cleaned between each sampling to prevent cross contamination.

Water samples were sealed in labeled, laboratory cleaned glass containers fitted with teflon septa. The samples were immediately placed on ice awaiting transportation to a state certified laboratory under proper chain of custody protocol. The Chain of Custody Record for samples tested is included in Appendix B.

Ground water elevations were measured to evaluate the ground water gradient. Evaluation of the ground water gradient across the site was made through the use of an automatic leveler, stadia rod, and electric water level indicator. The leveling instrument and stadia rod were used to measure the differences in elevation of the monitoring well casings for each of the monitoring wells. Measurements were recorded to the nearest 0.005 foot. The depth to ground water was measured with an electric water level indicator accurate to the nearest 0.01 foot. The relative water level elevation in each well was calculated from the measured data and used to construct a ground water potentiometric surface map for the site. The potentiometric map is shown on Figure 3, Appendix A. Interpretation of the map indicates that ground water flows to the north-northeast across the site under an approximate gradient of 0.3 feet per 100 feet (0.003). The flow direction is coincident with that expected from evaluation of the groundwater contaminant plume presented in Figure 4, Appendix A of Certified's Phase I Environmental Site Assessment.

### IV. SUMMARY OF ANALYTICAL RESULTS

The soil samples were submitted to Anametrix, Inc. of San Jose,
California for analysis. The chemical analysis for the soils and
water included the following:

TPH and BTEX - This analysis detects petroleum contamination and gasoline constituents. It was chosen to verify that none of the nearby petroleum fuel spills known to the RWQCB have affected the subject site.

Pesticides and PCBs - This analysis detects a wide range of pesticides and polychlorinated biphenyls. It was chosen to evaluate the presence or absence of pesticides in soils or ground water at the site.

PCB analysis was performed to evaluate the potential for on site contamination from the nearby electric substation. The electric substation is located at the intersection of Bowers Avenue and Augustine Drive.

Volatile organics - This analysis detects a wide range of
volatile organic compounds, including chlorinated
solvents. It was chosen to evaluate the presence
or absence of volatile organics in soil or
groundwater of the site, arising from on site or
off site activities. Solvents are commonly used
in high-technology operations and are known to be
present in a nearby contamination plume.

Certified analytical results are included in Appendix B. No petroleum hydrocarbons, gasoline constituents, pesticides or PCBs were detected in site soil and groundwater. Freon and a by-product of Freon was detected in water samples taken from the wells at the subject site. Freon was also detected in a soil sample from boring #2.

Freon (CFC 113) is widely used as a degreaser in the semiconductor industry, and is a common constituent in ground water contamination plumes in the Santa Clara Valley. The constituent migrates readily by vapor diffusion and may show complex groundwater from past behavior. In other ground water contaminant investigations where soil and groundwater conditions are better defined, Freon often is detected in advance of other constituents migrating in a groundwater plume.

Evaluation of the contamination levels detected on site indicate no significant variance between upgradient and downgradient wells.

Barring the potential for rapid vapor partitioning during sampling, the lack of statistical variance between upgradient and downgradient samples may be a semiquantitative indication that the Freon levels detected on site have migrated on site from an upgradient contamination source and present site background conditions.

According to Glen Hildebrand and Dave Spath, of the Santa Clara Health Department and Public Water Supply Branch, respectively, Maximum Contaminant Levels (MCLs) for Freon have not been established for local drinking water supplies. A MCL of 1.2 parts per million for Freon is proposed, however. Based on this level, the concentrations of Freon observed in site groundwater are several orders of magnitude below proposed drinking water standards.

#### V. CONCLUSIONS AND RECOMMENDATIONS

The detailed discussion and date provided above allows the following qualified conclusions regarding the environmental assessment of the subject property:

(1) Based on evaluation of the ground water gradient and flow direction across the site, the property is located in the downgradient direction from a contaminant plume containing chlorinated solvents. As discussed in the Phase I assessment, the plume is impinging upon the site.

- (2) Limited quantities of Freon have been used at the subject property, and Freon and its degradation products have been detected in site soil and ground water. A qualitative evaluation of ground water concentrations suggests that the Freon and its degradation product may be migrating on site from an upgradient source.
- (3) The detected levels of Freon are well below proposed regulatory drinking water criteria established for the protection of human health.

The conclusions, supported by the discussion in the text, allow the overall resolution that the environmental condition of the site has been marginally impacted. The impact may pose no threat to human health and the environment. However, the reported use of Freon on site and the presence of Freon in soil and groundwater may be adequate cause for regulatory concern.

It is recommended the corporate counsel be consulted for creation of an approximate financial mechanism within the framework of the property transfer agreement to allow for further evaluation of site hydrogeologic and hydrochemical conditions. At a minimum, site groundwater monitoring wells should be sampled quarterly for a period of one year to establish baseline ground water quality data.

Monitoring should proceed annually thereafter to assess the potential

for on site migration from upgradient sources. Further work may include installation of additional borings and monitoring wells to evaluate the potential impact of on site chemical usage on soil and groundwater quality.

#### VI. LIMITATIONS & SERVICE CONSTRAINTS

#### LIMITATIONS

The findings set forth in the attached Site Assessment Report are strictly limited in time and scope to the date of the evaluation(s). The conclusions presented in the Report are based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of agreed upon services or the time and budgeting restraints imposed by the client.

This report may contain recommendations which are partially based on the analysis of data accumulated at the time and place set forth in the report through subsurface exploration. However, further investigations may reveal additional data or variations of the current data which may require the enclosed recommendations to be reevaluated.

Chemical analyses may have been performed for specific parameters during the course of this site assessment, as described in the text. However, it should be noted that additional chemical constituents not searched for during the current study may be present in soil and/or groundwater at the site.

Partial findings of this investigation are based on data provided by others. No warranty is expressed or implied with the usage of such data.

### SERVICE CONSTRAINTS

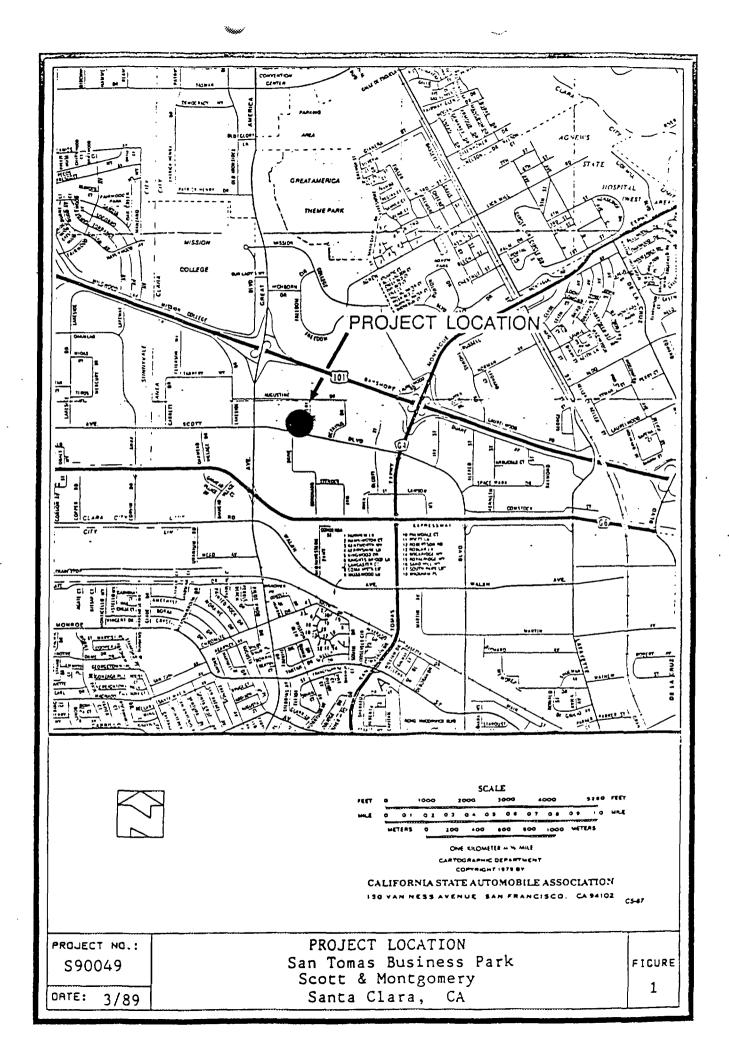
Much of the information provided in this report is based upon personal interviews and research of all available documents, records and maps held by the appropriate government and private agencies. This is subject to the limitations of historical documentation, availability and accuracy of pertinent records and the personal recollection of those persons contacted.

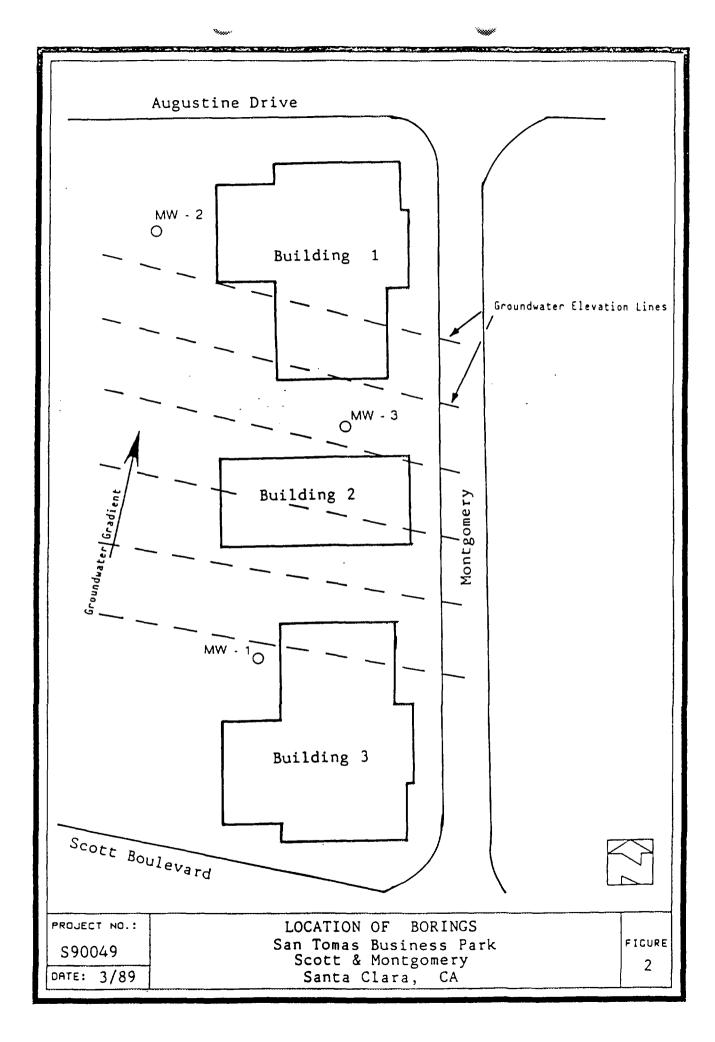
The initial site investigation took into account the natural and manmade features of the site, including any unusual or suspect
phenomenon. These factors, combined with the site's geology,
hydrology, topography and past/present land uses served as a basis for
choosing a methodology and location for subsurface exploration as well
as groundwater and subsurface sampling, if done. The subsurface data,
if provided, is meant as a representative overview of the site.

The location and analyses of soils, groundwater and surface water samples, if provided, was based on the same considerations listed in the paragraphs above. If samples were analyzed, they were analyzed for those parameter unique to the site as determined from the preceding site evaluation.

The presence of radioactive materials, biological hazards and asbestos was not investigated unless specifically noted otherwise.

This report is intended for the use listed in the section of this report described as the Introduction or Scope of Work. The use of this report in any other manner than that listed in the Introduction or Scope of Work requires the written consent of Certified Engineering and Testing Co., Inc. This report must be presented in its entirety.





# UNIFIED SOIL CLASSIFICATION SYSTEM

PRIME	IRY DIVIS	IONS		SECONDARY DIVISIONS
·	GRAVELS	CLEAN	\$0\$¢	Hell graded gravels, gravel-sand mixtures little an na fines.
0.11		GRAVEL	$\bigvee_{i}^{L}$	Poorly graded grevels or grovel-sand mix- runes, little or no fines
GRAINED		GRAVEL WITH	Q _∇	Silty gravels, gravel-sand-silt mixtures
- =		FINES		Clayey grovels, grovel=Sand=clay mixtures
COARSE	SANDS	CLEAN		Hell graded sands; grevelly sends.
COA		SANDS		Paerly graded sends or gravelly Sands.
	-	SANDS		Silry sands) sand-silr mixtures
	-	FINES		Clayey sands; sand-clay mixtures.
0,3	SILTS & (	CLAYS		Inorganic Silts and Vary fine SandS.
GRAINED		IT IS		Enorganic clays: gravelly clays, Sandy clays.
GRF	LESS THAN	50%	7	Organic siles and siley clays.  [norganic siles; niceceous fine sandy or
INE	SILTS & (	CLAYS	//	silry solls: elastic silts.
F 11	FIGNID FIW	IT IS		Inergenic clays of high plasticity.
	GREATER THE	N 50%		Organic clays 2 organic silts.
HIGHLY	ORGANIC S	OILS	$\bigotimes$	Pear and other highly organic Sails,

# RELATIVE DENSITY

SRHOS & GRAVELS	BLOWS/FOOT
VERY LOOSE	0 - 4
LOOSE	4 - 10
MED. DENSE	16 - 30
DEHSE	30 - 50
VERY DENSE	OVER 50

#### CONSISTENCY

SILTS & CLAYS	STRENGTH**	BLOWS/FOOT*
VERY SOFT	0 - 1/4	8 - 2
SOFT	1/4 - 1/2	2 - 4
FIRM	1/2 - 1	4 - 8
STIFF	ı - z	8 - 16
VERY STIFF	2 - 4	16 - 32
HARO	OVER 4	OVER 32

PROJECT NO.:	San Tomas Business Park	FIGURE
S90049	Scott & Montgomery	3
DATE: 3/89	Santa Clara, CA	

# CERTIFIED ENGINEERING & TESTING COMPANY **Environmental Consultants** 725 GREENWICH STREET • SUITE 204 • SAN FRANCISCO, CA 94133 MPLER (signature): Telephone: (415) 986-6872 FAX: (415) 986-4283 SHIPPING INFORMATION: BORATORY: Shipper _____ Address _____ Date Shipped ___ Service Used URNAROUND TIME: Airbill No. _____ olect Leader: Date. Time linquished by: (signatures) Received by signatures) 10:50 Received for laboratory by: 1 pmas ruleits BORATORY SHOULD SIGN UPON RECEIPT AND RETURN A COPY OF THIS FORM WITH THE LABORATORY RESULTS Sample Condition Date Analyses Sample Site Upon Receipt Sampled Requested No. Identification )-MW/ U-MINZ 2-Min 3 EDL RIVI COA RIXI TPHITTEX

#### METHOD 601/8010 REPORT

CONCENTRATION (ug/L)

Workorder # 310 (590049)

	W-MN1	M-HHZ	H-44-3		
COMPOUND	1 -0/	سد ه-	SAMPLE ID		
Chloromethane	1	j			
Bromomethane	1		1		1
Dichlorodiflouromethane	1	1	1	1	1
Vinyl Chloride	1		ĺ	1	
Chloroethane	<u> </u>	<u> </u>	1		
Methylene Chloride	<del> </del>	1	]	1	1
Trichloroflouromethane	1	<u> </u>	1 200 2 12	Į.	1
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1.1-Dichloroethane	}	1			1
cis-1.2-dichloroethene	1	JX:25 5%	1		1
Trans-1.2-Dichloroethene	1	1	Ì		1
Chloroform	1	<del> </del>	1		
Trichlorotriflouroethane	1 /3	18	1 /3		
1.2-Dichloroethane	1	<u> </u>	1		ŀ
1.1.1-Trichloroethane	1	1	1		
Carbon Tetrachloride	1	1		1	
Bromodichloromethane	1		1	1	1
1.2-Dichloropropane	1	1		1	
Trans-1.3-Dichloroprupene	1		1	1	1
Trichloroethene		1	- <del></del>	1	
1.1.2-Trichloroethane	!	<u></u> ]	<del></del>	<u> </u>	
cis-1.3-Dichloropropene	<del>/</del>		<u> </u>	<u> </u>	1
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2-Chloroethylvinyl Ether	<u>'                                      </u>	1	<u> </u>	1	1
Bromoform	!	<u> </u>	<u> </u>	Ì	ĺ
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Chlorobenzene	<u> </u>	1 .	1	1	
1.2-Dichlorobenzene	<del> </del>		1	1	1
1.3-Dichlorobenzene	<u> </u>	1	1		
1.4-Dichlorobenzene	<del>!</del>	1	1	1	1
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Analyst: OL	A Dichlorotri Fluoroethane conce
Date: 3/20/89	estimated based on trichlor
//	ethane calibration factor.

# METHOD 601/8010 REPORT FORM

CONCENTRATION (ug/b)- Kg)

Workorder # 8903110 (590049)

WOLDER # 0/23770 COS		5-14-82	5-13-83		
COMPCUND	704	-25-	SAMPLE ID		
Chloromethane	1			]	1
Bromomethane			Ī	1	
Dichlorodiflourcmethane	1	1 7 3	)i	1	
Vinyl Chloride			1	}	
Chloroethane	1	1	1	1	
Methylene Chloride		1	1	1	
Trichloroflouromethane	1	i		[	(
1.1-Dichloroethene	1	1	1	]	
1.1-Dichloroethane					
cis-1.2-dichloroethene	1	1	1	1	1
Trans-1.2-Dichloroethene	)		Î	1	·
Chloroform				l	
Trichlorotriflouroethane	i			1	
1.2-Dichloroethane	ſ				1
1.1.1-Trichloroethane					
Carbon Tetrachloride	1	1			
Bromodichloromethane			1		
1.2-Dichloropropane					
Trans-1.3-Dichloropropene			L		
Trichloroethene			1	L	
1.1.2~Trichloroethane			I		
cis-1.3-Dichloropropene		<u> </u>			
Dibromochloromethane		l			
2-Chloroethylvinyl Ether		l			
Bromoform					
1.1.2.2-Tetrachloroethane					
Tetrachloroethene		L			
Chlorobenzene		<u> </u>	<u> </u>		
1.2-Dichlorobenzene					
1.3-Dichlorobenzene		<u>L</u>	<u>L</u>		
1.4-Dichlorobenzene		<u> </u>	l		
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Dilution Factor	Horic	you	There !		
Instrument #	HD -7	HP-7	HE-7		
Date Analyzed	3/17/89	31.7,00	3/17/04		

Analyst	: <u>\$</u>	
Date: _	3/20/29	
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# certified Eng # 590049

## METHOD 608/8080 REPORT FORM

CONCENTRATION (ug/L)

590049 Workorder # <u>8903110</u>	Ju	9/L	<del></del>	€ Mg/k	(f
WIRDIGET # F) 777.3710			W-MN3		O .
COMPOUND	1 WALL	W-MW 2	SAMPLE ID		5-1-1-62
	1 01		43	1 28	
alpha-BHC	1 < 0.05	<u> </u>		<u> </u>	
beta-BHC	<del> </del>				
gamma-BHC (Lindane)					
delta-BHC		<u> </u>	<u> </u>	<u> </u>	
Heptachlor		<u> </u>	1		
Aldrin			1	<u> </u>	
Heptachlor epoxide		1.		1	
Endosulfan I		1	1	1 4	
p,p'-DDE	1 20.1	<u> </u>	1	1 <16	
Dieldrin			1	1	
Endrin	<u> </u>				1
p,p'-DDD	<u> </u>	<u> </u>		1	1
Endosulfan II	1	1		<u> </u>	1
p,p'-DDT		1			
Endrin aldehyde		1			<u></u>
Endosulfan sulfate		1		<i>y</i>	1
p,p'-Methoxychlor	1 40.5			<b>∠</b> So	<u> </u>
Endrin ketone	1 20.1		1	1 216	
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Toxaphene	41			1 <160	
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Aroclor 1242					
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Aroclor 1260	1 41			1 <160	
Aroclor 1016	1 <0.5	1		। ८५०	
	]				
% Surrogate Recovery	173	172	166	157	157
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Instrument #	1/41				<b>∤</b> `>
Date Analyzed	13:20				-1>

Analyst:	
Date:	
/1601	

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# METHOD 608/S080 REPORT FORM

CONCENTRATION (ug/L)

Workorder # 8905110 115/kg

COMPOUND	5-13-83	PS&K03178	SAMPLE ID 7 Pindikosi789	
alpha-BHC				
beta-BHC				
gamma-BHC (Lindane)				
delta-BHC				
		-		
Aldrin				
Heptachlor epoxide				
Endosulfan I				
p,p'-DDE		1		
Dieldrin		1		
Endrin	1			
p,p'-DDD	.1	1		
Endosulfan II	i .	1		
p,p'-DDT	1	1		
Endrin aldehyde	<u></u>			
Endosulfan sulfate	1			
p,p'-Methoxychlor				
Endrin ketone				
Technical chlordane	1	1		~ ·
Toxaphene				
Arcolor 1221	1	1		
Aroclor 1232		1		
Aroclor 1242	1	1		
Aroclor 1248		1		
Aroclor 1254	1			
Aroclor 1260				
Aroclor 1016				
% Surrogate Recovery	102	152	171	
Dilution Factor	NORP		+>	(
Instrument #	1/2/			
Date Analyzed	13-20		i->	

Analyst:	
Date:	
/1621	

### ANAMETRIX, INC. (408) 432 - 8192

## TOTAL FUEL HYDROCARBON REPORT

orkorder # <u>8903110</u>	)	
	5-10-81 -04 -06	SAMPLE ID
CONCENTRATION UNITS	lug/kin	
BENZENE	1 < 100	
TOLUEIE .	1 6100	
ETHYLBENZENE	2100	
XYLENES	<100	
gasoline	21000	
DIESEL		
TOG	!	
DATE ANALYZED		
GASOLINE		
DIESEL		
TOG		
GASOLINE RLMF *	501	
- <u>SOLINE</u> ate:3-20-8 ⁹		DIESEL Date:
nalyst:		Analyst:

METHODS DONE ARE THOSE SPECIFIED BY CRWQCB.
Anametrix, Inc. GC Department Form 2-1

### ANAMETRIX, INC. (408) 432 - 8192

# TOTAL FUEL HYDROCARBON REPORT

Workorder	<u># 8903)10</u>
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				5-13-E3	3
	W-MWI	Sample W - Mu Z	ID wmw3	-06	5-14-82
	-01	-02	-03	_ 李军_	-05
CONCENTRATION UNITS	117/8	27/8	19/0	1 /Kg	Ling/Kg
BENZENE	20.5	60.5	20.5	< 100	2100
TOLUENE			-	1	0, 1
ETHYLBENZENE					
XYLENES	21.	21.	21.		1 1
GASOLINE	2 50	250	< 50	L1000	41000
DIFSEL	NR:		NR	NR	N: /2_
TOG	1	<u> </u>	1		 
DATE ANALYZED	3-17-81	1	1		
GASOLINE	3-17-89		3-17-89	3-17-89	
DIESEL					
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GASOLINE RLMF *	1		/	501	2501

GASOLINE	DIESEL
Date: 3-20.8?	Date:
Analyst:	Analyst:

METHODS DONE ARE THOSE SPECIFIED BY CRWQCB.
Anametrix, Inc. GC Department Form 2-1

BORING B - 1 Lagged by: Tim O'Brien SHEET 1 of 1 Edited by: Tim O'Brien Orilling Contractor: Boylands Orilling Start Time/Date: 9:38 am/ 3-13-89 Drill Rig Type: CME 75 Oriller's Name: Tem/ Dave Completion Time/Date: 11:30 em/ 3-13-89 Hammer Wt.: 140# Drop:38" Sampler Type: California Medified Autohomner NCHES RECOVERED INCHES DRIVEN BLOUS/6" 090 Sii. C. 2 6 12 18 6 8 18 16 10 change to ten; stiff. OVR + 0. 12_ 14 Silty send (SN); fine-grained send; brown; 5101144 west he plasticity: lease. OVA = 0. 18 16 16. 18. 11 18 14 20 plasticity; medium dense. OVA + 0. 22. 7 12 16 24 Clayey silt (ML); greenish-grey;damp moist; moderate plasticity; very stiff. OVA . 0. THOMAS BUSINESS PARK PROJECT # 590047 SAN CERTIFIED DATE: 3/89 Santa Clara, CA

BORING B - 2 Logged by: Tim O'Brien Edited by: Tim O'Brien SHEET 1 of 1 Orilling Contractor: Baylands Orilling Orill Rig Type: CME 75 Stert Time/Dete: 1:88 pm/ 3-13-89 Oriller's Name: Tom/ Dave Completion Time/Date: 7:38 pm/ 3-13-89 Drop: 38* Hommer Wt.: 140* Sampler Type: California Madified Autohammer RECOVERED DRIVEN Odor 2 Clay (CH) w/ trace fine-coarse sand and trace fine gravel; black; Slightly damp-maiss; high plassicity; very stiff. 5 11 12 Clay (CL) w/ Some Silt: ten: damp -10. very stiff. OVA = 0. 12. Clay m/ some silt as above: very meist-met; stiff. OVR = 0. 16_ 18. 18 Clay (CH); brown; very mais:-wer: high 20. plasticity; very stiff. OVA + 0. 22. evel & sand. OVA = 0. THOMAS BUSINESS PARK PROJECT # 590047 SAN CERTIFIED DATE: 3/89 Santa Clara, CA

BORING 8 - 3 Tim O'Brien SHEET 1 of 1 Edited by: Tim O'Brien Orilling Contractor: Baylands Orilling Drill Rig Type: CME 75 Start Time/Date: 9:38 am/ 3-14-89 Driller's Name: Tom/ Dave Completion Time/Date: 11:38 am/ 3-14-89 Hammer W1.: 140# Drop: 30° Sampler Type: California Madified Rutchemner INCHES RECOVERED INCHES DRIVEN 040 Slip Cop 2 Blank Casing 6 12 14 -high plasticity; very stiff. DVR+0. 6 Bentonite Silvy clay (CL); greenish-grey; maist; moderate plasticity; stiff. OVA = 8. 18 10. 12. DVA . 0. 16_ 18. Clayey Silt (ML) m/ trace sand and gravel; 18 14 20. 22. Silty clay (CL); grey; moderate plasticity; 18 medium stiff. OVA = 8. PROJECT # 590047 THOMAS BUSINESS PARK SAN CERTIFIED DATE: 3/89 Santa Clara, CA

# Introduction to Exploration Geochemistry

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Table 2.1 (Continued)

The Primary Environment

Element	Earth's crust	Uline- mefic	Beselt	Grane- diorite	Granite	Shele	Lime	Sell	River
Rh	0.0004	_	_	_	_	_	_		_
Ro .	0.0004	_		_	-	_	_	_	_
<b>S</b>	0.2	0.1	0.2	0.2	0.2	ı	_	5	1
Se	16	10	30	10	5	15	5	_	0.004
Sa	0.05	-	0.05	-	0.03	0.6	0.08	0.2	0.2
<b>\$</b>	6	0.57	4.2	6.0	3	•	0 8		0.03
Se .	2	0.5	1	2	3	4	4	10	_
Ser	375	ı	465	450	285	300	500	50-1000	50
Ta	2	ı	0.5	2	3.5	2	_	_	_
Th	0.9	0.088	0.63	1.3	0.05	1	_	_	0.000
To	0.00 i	0.001	0.001	0.001	0.001	0 01	_	_	_
Th	10	0.003	2.2	10.	17	12	2	13	0.1
Ti	5700	3000	9000	8000	2300	* 4600	400	5000	3
TI	0.43	0.05	0.1	0.5	0.75	0.3		0.1	_
T=	0.48	0.053	0.21	0.5	-	0 2	0.1	_	0.00
U	2.7	0.001	0.6	3	4.8	4	2	1	0.4
V	135	50	250	100	20	130	15	20-500	0.9
W	1.5	0.5	1	2	2	2	0.5	_	0.03
Y	30	_	25	30	40	25	15	_	0.7
Yb	3	0.43	1.11	3.6	0.06	3	0.1	_	0.03
Ze	70	50	100	60	40	100	25	10-300	20
Zr	165	50	150	140	180	160	20~	300	_

- 1. Dashes (-) indicate no data are available.
- 2. Earth's crust: All data from Taylor (1964, 1966) except for Mn. Ti and Se (Saxby, 1969); Re, Ir, Os, Pd, Pt, Rh and Ru (appropriate chapters in Wedepohl, 1969); Te (Parker, 1967).
- 3. Igneous rocks, shales and limestones: All data from Taylor (1964, 1966, 1969) except for Mm, TI and Se (Andrews-Jones, 1968; Saxby, 1969); Re, Ir, Os, Pd, Pt, Rh and Ru (appropriate chapters in Wedepohl, 1969); Te (Parker, 1967); F. Cl, Br and I (Turckian and Wedepohl, 1961).
- 4. Soil: All data from Taylor (1966) except for Ag, Cs, Hg, Hf, Mn, Sb, Ti, Tl and Zr (Saxby, 1969, who also reports total rare earth elements in soils as approximately 100 ppm); Th
- 5. River water data from Turckian (1969) except for chlorine (Livingstone, 1963) and uranium (Reeder et al., 1972). All rare earth element data (except La) are estimates by Turekian.

The list also includes average abundances of these trace elements in the crust (which is itself considered equivalent to the average value for all igneous rocks), shale, limestone, soil and river water, since these values will be discussed later. The compilation of "average" amounts is beset with many difficulties, particularly as the Earth's crust is not uniform and we can sample only to relatively shallow depths. Thus, although reliable sources (chiefly Taylor, 1966) were used in compiling Table 2-1, the values are subject to change as new data are obtained. Further, as will be noted in the discussion of geochemical provinces, the trace and minor element content of rocks with the same name (e.g., granite) can vary significantly. This is particularly true for the rarer elements in rocks generally, and especially

## Distribution of Trace Elements

As the major and minor element composition of a magma changes with differentiation, so too does the trace element composition. A comparison of the minor and trace (<0.1%) element composition of important igneous rock types is presented in Table 2-1, which lists the average abundance of 65 elements of particular interest in exploration geochemistry.

Table 2-1. Average abundance (or range) of selected minor and trace elements in the Earth's crust, various rocks, soil and river water. (All values in ppm, except those for river water which are ppb).

Element	Earth's Crust	Ulire- mafic	Basalt	Grane- diorise	Granke	Shale	Lime- sione	Soil	River water
Ag	0.07	0.06	0.1	0.07	0.04	0.05	1	0.1	0.3
As	1.8	1	2	2	1.5	15	2.5	1-50	2
Au	0.004	0.005	0 004	0.004	0.004	0.004	0.005	1-30	0.001
8	10	5	5	20	15	100	10	2-100	10
De .	425	2	250	500	600	700	100	100-3000	
De	2.8	-	0.5	2	5	3		6	
	0.17	0.02	0.15		0. L	0.18	·_	•_	_
Br	2.5	1	3.6	_	2.9	4	6.2	_	20
Cd	0.2	_	0.2	0.2	0.2	0.2	0.1	1	20
Ce	60	•	35	40	46	50	10	·_	0.06
CI	130	85	60	_	165	180	150	_ 7	
Co	25	150	50	10	1	20	4	1-40	0.2
Cr	100	2000	200	20	4	100	10	5-1000	1
Ça	3	_	1	2	Š	3		6	0.02
Ç.	55	10	100	30	10	50	15	2-100	7
Dy	3	0.59	3	3 2	0.5	3	0.4	-	0 05
Er	2.8	0.36	1.69	4.8	0.2	ž	0.5	_	
Eu	1.2	0.16	1.27	1.2	-	i	-	_	0.03
F	625	100	400	_	735	740	330		100
Ga .	15	1	12	18	18	20	0.06	15	0.09
G <b>4</b>	5 4	0 65	4.7	7.4	2	4	0.6	13	
Ge	1.5	1	1.5	i	1.5	1.5	0.6		0.04
Hf	3	0.5	2	ž	4	3	0.5	•	_
Hg	0 08	_	0.08	0.06	0.08	0.5	0.05	0.03	0.007
Ho	1.2	0.14	0.64	1.6	0.07	1	0.03		
1	0.5	0.5	0.5	_	0.5	2.2	1.2	_	0.01
le	0.1	0.01	0.1	0.1	0.1	0.1			7
le	0.0004	~	_	_	-		0.02	-	_
La	30	3.3	10.5	36	25	20	-	_	_
LI	20	_	10	25	30	60	20		0.2
L	0.50	0.064	0.20		0.01	0.5	20	5-200	3
Ma	950	1300	2200	1200	500	850	1100	850	
Me .	1.5	0.3	1	1	2	3	1100		7
Nb	20	15	20	20	20	20	•	2	1
Nd	28	3.4	17.8	26	18	24	3	_	0.2
Ni	75	2000	150	20	0.5	70	12	5.500	
Os	0 0004	_	-		0.5	70_	12	3.300	0.3
h	12.5	0.1	5	15	20	20	ī	2.200	
N	0 004	0.02	0 02		0 002	40	•	2-200	3
Pr	6.2	1.02	3.9	8.5	4.6	_		_	0.03
ħ	0.002	0.02	0.02	_	0.008	_	'_	_	U.U3
Rb	90		30	120	150	140	5	20.500	
Re	0.0005		0.0005		0.0003	170	,	4U-3UU	•

# E

# GEOCHEMICAL CHARACTERISTICS OF SELECTED ELEMENTS

In this appendix, modelled after a similar appendix originally presented by Hawkes and Webb (1962), important geochemical characteristics are compiled for the trace elements which are of most importance in exploration geochemistry. Emphasis has been given to those characteristics which affect the development of secondary dispersion halos (anomalies).

The main sources of the data used in this compilation are:

IGNEOUS ROCKS: Table 2-1 (pp. 43-44).

SEDIMENTARY ROCKS: Table 2-1; sandstone, Beus and Grigorian (1977); black shale (for a limited number of elements), Vine and Tourtelot (1970); and Wedepohl (1969-1974) in some cases.

Soils: Table 2-1. Also, Aubert and Pinta (1977) for soils in temperate, arid, and tropical humid regions; data are only available for a limited number of elements. In the case of the Aubert and Pinta (1977) data, ranges are generally given which exclude exceptionally high and low values.

SURFACE WATERS: Table 2-1.

VEGETATION ASH: Beus and Grigorian (1977; Table 46), and Table 10A-2 (this volume). For biological response, Table 10A-1, Boyle (1974a), and other miscellaneous sources.

GEOCHEMICAL ASSOCIATIONS: Table 2-4, Fig. 2-5 and Table 2A-7 of this volume; Boyle (1974a); and Wedepohl (1969-1974).

Substitutions in: Tables 2-2, 2-5 and 2A-6 of this volume; Boyle (1974a); and Wedepohl (1969-1974).

MOBILITY - SECONDARY ENVIRONMENT: Fig. 3-19, Tables 3A-3 and 3A-4 of this volume; Boyle (1974a); and Perel'man (1977).

GEOCHEMICAL BARRIERS: Fig. 3-19, Tables 2A-1 and 3A-3 of this volume; Boyle (1974a); and Perel'man (1977).

PATHFINDERS: Tables 2-3 and 3A-4 of this volume; and Boyle (1974a).

Data for all other categories were obtained from various scattered sources. Where there are no data, entries for the particular category (e.g., aqueous phase) have been omitted.

Boyle (1974a) is highly recommended to those who are interested in further-information on the geochemical characteristics of the elements. This is clearly the most comprehensive compilation of elemental associations and indicator (path-finder) elements available which is designed primarily for exploration geochemistry.

Abbreviations: Av — average; INTER — intermediate (granodiorite); SH — shale; BLSH — black shale; Ss — sandstone; Ls — limestone; TEMP — temperate; TROP (HUM) — tropical humid.

VEGETATION ASH (ppm): .01.

COMMENTS: The geochemistry of Cd is essentially identical to that of Zn, for reasons explained on p. 66, and sphalerite always contains Cd generally in the range of 1000-5000 ppm (Table 2-5). In some situations Cd may become enriched relative to Zn (e.g., hydrothermal zoning; see Fig. 7-3). During the weathering of Cd-containing zinc minerals, secondary Cd minerals, such as greenockite (CdS) and otavite (CdCO₃), may form. See Zinc in this appendix.

#### CERIUM (Ce)

BONBOUS ROCKS (ppm): Av 60; Mafic 35; Inter 40; Felsic 46.

SEDIMENTARY ROCKS (ppm): SH 50; Ss 90; Ls 10.

SOLS (opm): Av~5.

SURFACE WATERS (ppb): Av 0.06.

20ETATION ASH (ppm): 30; although Ce has been found in numerous plants, its value in exploration is poorly documented.

GEOCHEMICAL ASSOCIATIONS: Lithophile; RE, Li, Rb, Cs, Be, Nb, Ta, Zr, B, Th, U, and F in pegmatites; RE, Th, P, Zr, Fe, and Cu in monazite veins; RE, Th, Ba, Sr, P, F, and C in carbonatites; RE, U, P, and F in phosphorites; RE, Au, Ti, Sn, Zr, and Th in placers.

ORE MEMERALS: monazite, bastnaesite, cerite, xenotime.

SUBSTITUTIONS IN: apatite, alianite, sphene, fluorite, niobate-tantalates (e.g., euxenite), feldspar (Eu concentrated).

SORS; OCCURRENCE IN: limonite, clays; possibly as insoluble phosphates (e.g., rhab-dophane, florencite).

AQUBOUS PHASE: soluble only under acid conditions (pH of hydrolysis is 2.7; Table 3-6); also forms complexes with organics and carbonates (Wedepohl, 1969-1974).

MOSILITY — PRIMARY ENVIRONMENT: high; concentrates in late stage granites and pegmatites; highly concentrated in some alkalic rocks, including carbonatites.

MOSELITY - SECONDARY ENVIRONMENT: low in solution even though some Ce nerals (e.g., the fluorearbonates such as bastnaesite) are unstable; primarily as detrital monazite, xenotime, etc.

GEOCHEMICAL BARRIERS: pH; mechanical.

CE IS A PATHFINDER FOR: other rare earths and Th in carbonatites; other elements in associated deposits (e.g., Ti or Sn in placers).

PATHFINDERS FOR CE ARE: The rare-earth elements, P, F, and other elements in the specific geochemical association (e.g., Th. Nb, U); however, orientation studies should precede actual surveys to determine nature of dispersion (chemical or mechanical) and general suitability of proposed survey.

COMMENTS: Cerium is the most abundant (about 30% of the total) of the 16 rare earth (RE) elements which consist of Y and La-Lu (atomic numbers 39 and 57-71). As a rule, all the rare earth (RE) elements accompany each other in specific relative abundances, and they all have essentially identical geochemical charac-

teristics (e.g., similar mobility in all environments) but, in fact, separations are frequent. For example, Ce, La and the other "light" RE elements concentrate in monazite, allanite, and other minerals in carbonatites, whereas Y, Er, Yb and Lu and the other "heavy" RE elements concentrate in xenotime, and fluorite. Likewise, Od, Tb and Dy concentrate in certain minerals (e.g., gadolinite).

#### CHROMIUM (Ct)

IGNEOUS ROCKS (ppm): AV 100; MAFIC 200; INTER 20; FELSIC 4.

SEDIMENTARY ROCKS (ppm); SH 100; SS 35; Ls 10.

Soils (ppm); Av 50. Range 5-1000; Temp 7-300; Anid 200-500; Trop (Hum) 150-300.

SURFACE WATERS (ppb): AV 1.

VEGETATION ASH (ppm): 90; poor biological response.

GEOCHEMICAL ASSOCIATIONS: Siderophile; Cr. Co, Ni, Cu, Pt-group.

ORE MINERALS: chromite.

SUBSTITUTIONS IN: micas (fuchsite, meriposite, Cr-micas) and garnets; in absence of chromite, Cr substitutes in pyroxene and magnetite in basic rocks.

Soils: Occurrence in: chromite, limonite.

SECONDARY MINERALS: none; but serpentine may contain minute chromite grains.

AQUEOUS PHASE: effectively insoluble except under very acid-oxidizing conditions as chromate ion.

MOBILITY - PRIMARY ENVIRONMENT: low; concentrates in ultrabasic rocks.

MOBILITY - SECONDARY ENVIRONMENT: only as detrital chromite (very stable); concentrates in heavy fraction of soils and sediments.

GEOCHEMICAL BARRIERS: mechanical.

CR IS A PATHFINDER FOR: chromite, platinum, and other ultramalic deposits.

PATHFINDERS FOR CR ARE: Ni, Co, Cu.

COMMENTS: Cr has been successfully used in soil, sediment and heavy mineral surveys (but not hydrogeochemical) based primarily on the stability of chromite.

#### COBALT (Co)

IGNEOUS ROCKS (ppm): Av 25; MAFIC 50; INTER 10; FELSIC 1.

SEDIMENTARY ROCKS (ppm): SH 20; BLSH 10-20; SS 0.3; LS 4.

SOILS (ppm): Av 10. RANGE 1-40; TEMP 1-45; ARID 10-100; TROP (HUM) 1-50.

SURFACE WATERS (ppb): AV 0.2.

VEGETATION ASH (ppm): 15; biological response satisfactory (Table 10A-2 but see p. 384).

GEOCHEMICAL ASSOCIATIONS: Siderophile; also chalcophile. Ni, Co, Pt, Fe, Cu, Ag, Au, Se, Te, and S in Ni-Cu massive sulfide deposits; Ni, Co, Ag, Fe, Cu, Pb, Zn, As, Sb, Bi, and U in Cu-Co sulfide ores; with certain Au and Ag ores; Ni, Co, Fe, Mn, and Cr in laterites; Mn, Ni, Cu, Zn, and Co in deep-sea Mn nodules (Table 3-10); see Uranium in this appendix for U associations.

ORE MINERALS: cobaltite, smaltite.

SUBSTITUTIONS IN: Ni minerals; pyrite, sphalerite and other sulfides (Table 2-5); in some Fe-Mg silicates.

SOILS; OCCURRENCE: strongly adsorbed by Mn oxides (pp. 135, 384); also adsorbed by limonite and clay (Table 3-3).

SECONDARY MINERALS: erythrite (cobalt bloom).

AQUEOUS PHASE: as ionic Co1+.

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in hydrothermal veins where it forms sub-ore halos (Fig. 7A-6); also low, as it occurs in some ultrabasic occurrences.

MOBILITY - SECONDARY ENVIRONMENT: good; pH of hydrolysis is 6.8 (see also Fig. 6-3).

GEOCHEMICAL BARRIERS: sulfide; adsorption; pH.

COBA PATHFINDER FOR: all deposits in which it occurs, e.g., Cu (in shales), Ni-Cu (massive sulfide), U (vein type), and certain Ag and Au veins; see Table 3A-4.

COMMENTS: Co can be used in practically all types of surveys: soil, sediment, water, vesetation, and till. See Boyle (1974a) for additional information.

#### COPPER (Cu)

IGNBOUS ROCKS (ppm): Av 55; MAFIC 100; INTER 30; FELSIC 10.

SEDIMENTARY ROCKS (DDM): SH 50; BLSH 70-150; SS 10; LS 15.

Soils (ppm): Av 20. Range 2-100; Temp 25; Arid 15-100; Trop (Hum) 10-150.

URFACE WATERS (ppb): AV 7.

VEGETATION ASH (ppm): 20; biological response fair (Table 10A-2) although Cu is often considered a "difficult" element (p. 407); Cu can cause barren areas (Fig. 10A-3).

GEOCHEMICAL ASSOCIATIONS: Chalcophile; Cu, Pb, Zn, Cd, Ag, Fe, As, Sb in massive sulfide (volcanogenic) type deposits; Cu, Mo, Re, Fe in porphyry Cu type deposits; Ni, Cu, Pt, Cr in ultrabasic Pt deposits; Ag, Zn, Pb, Mo, Co in copper shale deposits (e.g., Kupferscheifer).

ORE MINERALS: chalcopyrite, bornite, other sulfides, native Cu.

SUBSTITUTIONS IN: pyroxene, amphiboles, magnetite, biotite.

SOILS; OCCURRENCE: adsorbed by clays, Fe-Mn oxides, and organic matter.

SECONDARY MINERALS: many carbonates, sulfides, oxides, sulfates, and silicates.

AQUEOUS PHASE: ionic (Cu2+, Cu+); organic complexes.

MOBILITY - PRIMARY ENVIRONMENT: high, as in the case of porphyry copper deposits in felsic rocks; low, as in case of Pt-Cr occurrences in ultrabasics.

MOBILITY - SECONDARY ENVIRONMENT: high in oxidizing, acidic waters; low in alkaline and reducing waters.

GEOCHEMICAL BARRIERS: sulfide; adsorption; pH (pH of hydrolysis = 5.5).

CU IS A PATHFINDER FOR: all types of deposits in which it occurs.

PATHFINDERS FOR CU ARE: Mo in porphyry copper deposits; other chalcophile elements (e.g., Zn, Co) are used in hydrogeochemical surveys for Cu deposits when waters are alkaline.

COMMENTS: Cu is one of the most commonly determined elements in exploration geochemistry using all types of sampling media (soils, sediments, waters, vegetation, etc.). See Boyle (1974a) for additional information.

#### FLUORINE (F)

IGNEOUS ROCKS (ppm): AV 625; MAPIC 400; INTER 500; FELSIC 735.

SEDIMENTARY ROCKS (ppm); SH 740; SS 270; LS 330.

SOILS (ppm): AV 200.

SURFACE WATERS (ppb): AV 100.

VEGETATION ASH (ppm): 10; poor biological response (Table 10A-1).

GEOCHEMICAL ASSOCIATIONS: Lithophile; F, Ca, Fe, S, Si, Ba, Sr, Pb, Zn, and Cu in veins and stockworks; F, Al, Ca, Sn, Mo, and W in greisen zones; Nb, Ta, P, F, Ti, and rare-earths in carbonatites; F, U, V, Se, As, and rare-earths in phosphorites; Pb, Zn, Ba, and F in carbonates (Mississippl Valley type).

ORE MINERALS: fluorite, topaz.

SUBSTITUTIONS IN: apatite, mica, amphibole, tourmaline.

SOILS: OCCURRENCE IN: secondary phosphates, apatite, fluorite, adsorbed by Aloxides.

AQUEOUS PHASE: as fluoride ion (F-).

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in granites, pegmatites, late stage hydrothermal veins, and carbonatites.

MOBILITY - SECONDARY ENVIRONMENT: high; soluble under all environmental conditions.

GEOCHEMICAL BARRIERS: calcium barrier (causes precipitation of fluorite) limits solubility of F; adsorption (by Al oxides).

F IS A PATHFINDER FOR: many types of deposits (see below).

PATHFINDERS FOR FARE: F. and associated base metals.

COMMENTS: Boyle (1974a, p. 36) states, "Fluorine is a persistent constituent of almost all types of mineral deposits, occurring in amounts from traces to minor and major. The element is, therefore, almost the universal indicator of mineralization. The other elements of almost universal occurrence in mineral deposits are boron and sulphur. These three elements used on conjunction with one another provide a

formidable array of indicators in geochemical prospecting for practically all types of deposits. Where one element fails to serve another will in most cases." (Note: phosphate fertilizer may contain F which can result in high values for streams).

#### GOLD (Au)

IGHEOUS ROCKS (ppm): Av 0.004; MAFIC 0.004; INTER 0.004; Felsic 0.004.

SEDIMENTARY ROCKS (ppm): SH 0.004; Ls 0.005.

**Soit.s** (ppm): Av 0.001.

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SURFACE WATERS (ppb): AV 0.002.

VEGETATION ASH (ppm): 0.005; the value of biogeochemical methods in gold exploration are dubious at present.

EOCHEMICAL ASSOCIATIONS: Siderophile (also noble); in quartz veins generally with SiO₂, Ag, As, Sb, S, and Fe; Fe, Zn, Pb, Cu, and Mo in sulfide deposits; in placers with U (South Africa), or other elements in heavy minerals.

ORE MINERALS: native gold, tellurides.

SUBSTITUTIONS IN: native silver, in sulfides it probably occurs as minute inclusions and not in isomorphous substitution.

SOILS: OCCURRENCE IN: dissolved and re-precipitated native gold.

AQUEOUS PHASE: soluble organic complexes, chloride complexes, and other mechanisms have been proposed.

MOSSLITY - PRIMARY ENVIRONMENT: concentrates in hydrothermal veins; also concentrated in some perphyry copper deposits.

MOBILITY - SECONDARY ENVIRONMENT: for all practical purposes only mechanical mobility as native gold.

**GBOCHEMICAL BARRIERS: mechanical (Table 2A-1).** 

AUBAPATHFINDER FOR: has been proposed for porphyry copper (p. 54).

PATHFINDERS FOR AU ARE: Ag, As, Sb, Bi, and W in placers or rocks (Te and Hg iso in some cases); the same elements plus Cu, Se and Te in plant ash may be useful indicators.

COMMENTS: See Boyle (1974a) for further information.

#### LEAD (Pb)

IGNEOUS ROCKS (ppm): AV 13; MAFIC 5; INTER 15; FELSIC 20.

**SEDIMENTARY ROCKS (ppm):** SH 20; BLSH 20-70; Ss 7; Ls 8.

SOILS (ppm): Av 20. RANGE 2-200; TEMP 40; ARID 20; TROP (HUM) 20.

SURFACE WATERS (ppb): Av 3.

VEGETATION ASH (ppm): 10; generally fair to good biological response; can cause barren areas (Fig. 10A-2).

GEOCHEMICAL ASSOCIATIONS: Chalcophile; most lead deposits contain Ag, Zn, Cd and Cu; sulfide deposits with Pb contain Ag, Zn, Cd, Cu, Ba, Sr, V, Cr, Mn, Fe, Ga, In, Tl, Ge, Sn, As, Sb, Bi, Se, Hg, and Te. In carbonates (Mississippi Valley type) with Zn and Cd.

ORE MINERALS: galena.

SUBSTITUTIONS IN: K-feldspar, plagioclase, mica, zircon, magnetite (Table 2A-4).

Soils; Occurrence in: relatively stable galena, anglesite, and cerussite in heavy fractions; ionic Pb2+ accumulates by adsorption in humic and clay horizons.

SECONDARY MINERALS: cerussite, anglesite, pyromorphite.

AQUEOUS PHASE: ionic Pb2+ in most waters; complexing with chloride in brines.

MOBILITY - PRIMARY ENVIRONMENT: high; accumulates in granitic rocks and hydrothermal veins; forms supra-ore halos (Figs. 7-5, 7A-10, 7A-11).

MOBILITY — SECONDARY ENVIRONMENT: generally low in most oxidizing and gley environments but immobile in reducing sulfide environment; forms very insoluble carbonate, sulfate, and phosphate minerals; galena, cerussite, and anglesite move mechanically in the heavy fractions of sediments and soils.

GEOCHEMICAL BARRIERS: sulfide; carbonate; sulfate; adsorption; pH (pH of hydrolysis = 6.0).

PB IS A PATHFINDER FOR: Pb deposits; U deposits; polymetallic vein deposits.

PATHFINDERS POR PB ARE: Zn, Cd, Ag, Cu, Ba, As, and Sb.

COMMENTS: The use of isotopic analysis of lead minerals (discussed in Chapters 7 and 7A) has significant exploration potential.

#### LITHIUM (LI)

IGNEOUS ROCKS (ppm): AV 20; MAFIC 10; INTER 25; FELSIC 30.

SEDIMENTARY ROCKS (ppm): SH 60; SS 15; LS 20.

Soils (ppm): Av 30. RANGE 5-200; TEMP 30; ARID 30; TROP (HUM) 30.

SURFACE WATERS (ppb): AV 3.

VEGETATION ASH (ppm): 6; biological response good.

GEOCHEMICAL ASSOCIATIONS: Lithophile; Li, Be, B, K, Rb, Cs, Nb, Ta, F, P, Sn, W and rare earths in granite pegmatites; Li, B, F, Be, Sn, W, and Mo in greisens; Li, Na, K, B, P, W, F, Br, Cl, I, SO₄ and CO₃ in brines and saline evaporites (e.g., Searles Lake, California).

ORE MINERALS: spodumene, lepidolite, amblygonite; also economic deposits in brines (Searles Lake; Silver Peak, Nevada; Great Salt Lake, Utah).

SUBSTITUTIONS: for Mg in micas (especially biotite) and hornblende.

Soils: occurrence in: Mn oxides (p. 135) and clays.

AQUEQUS PHASE: ionic Li+.

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in granites and pegmatites.

MOBILITY - SECONDARY ENVIRONMENT: relatively mobile in all environments (although it is the least mobile of the alkalis).

GEOCHEMICAL BARRIERS: adsorption (by Mn oxides and clays).

LIES A PATHFINDER FOR: pegmatite deposits; hydrothermally altered tuffs containing Be and fluorite (Spor Mtn., Utah); greisens; deep-seated brines containing Li by analyzing vegetation (Cannon et al., 1975); recognizing mineralized granites (Tables 7-1, 7-2, 2A-9).

PATHIPHDERS FOR LIARE: Li, Sn, Nb, W, etc., in heavy resistate minerals of soils and sediments in permatite and greisen areas; B and W for Li-containing brines.

COMMENTS: See Boyle (1974a) for additional information.

#### MERCURY (Hg)

IGNEOUS ROCKS (ppm): Av 0.08; MAFIC 0.08; INTER 0.08; FELSIC 0.08.

COMENTARY ROCKS (ppm): SH 0.5; SS 0.07; LS 0.05.

#LS (ppm): Av 0.03.

SURFACE WATERS (ppb): AV 0.007; up to 200 ppb in waters from hot springs.

VEGETATION ASH (ppm): 0.001; biological response for exploration purposes waknowa.

**GEOCHEMICAL ASSOCIATIONS:** chalcophile; Hg. Sb. As and sometimes Sn and W; in some gold-quartz and silver (e.g., Cobalt type) veins; in some Zn vein deposits. ORE MINERALS: cinnabar, native mercury.

SUBSTITUTIONS IN: sphalerite (Table 2-5), tetrahedrite, tennatite, and other sulfides.

SOILS: OCCURRENCE IN: cinnabar, native mercury, Hg vapor, and organic complexes.

AQUEOUS PHASE: probably as soluble sulfide complex (especially in thermal waters), and as organic complexes.

MOBILITY - PRIMARY ENVIRONMENT: highly mobile; concentrates in late stage, low . temperature veins and stockworks; forms supra-ore halos.

MORELTY - SECONDARY ENVIRONMENT: low in surface waters; high in thermal waters; high in vapor phase; also mechanical transport (in the heavy fraction) because cinmaber is very stable.

CHEMICAL BARRIERS: sulfide, adsorption (by organic matter).

HG IS A PATHFINDER FOR: base metal (particularly Zn-Pb-Ag) deposits; certain types of Au deposit (e.g., Carlin-type).

PATHEMPERS FOR HG ARE: So and As; high content of Hg in placer gold suggests proximity to Hg deposits.

COMMENTS: Discussions on the use of Hg in geochemical exploration will be found in Chapters 7 and 7A. Instrumentation is discussed in Chapters 6 and 6A.

#### MOLYBDENUM (Me)

IGNEOUS ROCKS (ppm): AV 1.5; MAFIC 1; INTER 1; FELSIC 2. SEDIMENTARY ROCKS (ppm): SH 3; BLSH 10; Ss 0.2; Ls 1.

SOILS (ppm): AV 2. TEMP 1-5; ARID 2-5; TROP (HUM) 1-5.

SURFACE WATERS (ppb): AV 1.

VEGETATION ASH (ppm): 9; good biological response (Tables 10A-1, 10A-2).

GEOCHEMICAL ASSOCIATIONS: Chalcophile and siderophile; Mo, W, Re, Cu, Sn, Be, B, F, P, Zn, Bi, and Fe in pegmatites; Mo, Bi, W, F, and Be in griesens; Mo, Cu, Re, Ag, Au, and Zn in prophyry copper deposits; Mo, U, Se, V, and Cu in sandstone-type U deposits.

Geochemical Characteristics of Selected Elements

ORE MINERALS: molybdenile; minor powellite and wulfenite.

SUBSTITUTIONS: for W in tungsten minerals (e.g., scheelite and wolframite); does not substitute in silicates or sulfides to any significant degree.

SOILS; OCCURRENCE IN: molybdenite, ferrimolybdite, wulfenite, and powellite; adsorbed on organic matter (Fig. 3-18) and limonite.

SECONDARY MINERALS: ferrimolybdite, powellite, wulfenite; secondary molybdenite (in hydrogen sulfide environment); also as ilsemannite (Mo₁O₂·nH₂O), which occurs as a deep blue stain, and is the result of Mo in molybdate-containing solutions being reduced from Mo⁶⁺ to Mo⁵⁺ (as in the sandstone U deposits in the U.S.).

AQUEOUS PHASE: molybdate (MoO₄2; Fig. 3-20).

MOBILITY - PRIMARY ENVIRONMENT: high; enriched in granites, pegmatites, high temperature hydrothermal veins, and porphyry copper deposits.

MOBILITY - SECONDARY ENVIRONMENT: high in oxidizing, alkaline environments but low in scidic (the reverse of copper); low in reducing environments; mobility restricted by presence of Pb (forms wullenite). Fe (forms ferrimolybdite), and carbonate (forms powellite); molybdenite weathers slowly in some climates and may be found as detrital grains in the heavy fractions of soils and sediments.

GEOCHEMICAL BARRIERS: sulfide; reducing; adsorption; special ions (e.g., Pb, Fe, carbonate).

MO IS A PATHFINDER FOR: molybdenum, porphyry copper, and sandstone-type U deposits.

PATHFINDERS FOR MO ARE: Cu, W, and Bi; F and some of the other associated elements in some types of occurrences.

COMMENTS: Mo is an excellent indicator of deposits containing this element and can be determined in all types of surveys utilizing soils, sediments, spring precipitates, vegetation, bogs, etc. Boyle (1974a) notes that during the weathering of deposits that contain both quartz and molybdenite, the highly resistant quartz in eluvium, soils and sediments should be examined closely for the presence of molybdenite; this applies particularly to cobbles and boulders which are not normally collected for analysis. See Boyle (1974a) for additional information on the geochemistry of Mo.

#### NICKEL (NI)

IGNEOUS ROCKS (ppm): AV 75; MAFIC 150; INTER 20; FELSIC 0.5.

SEDMENTARY ROCKS (ppm): SH 70; BLSH 50-200; SS 2; LS 12.

SOILS (ppm): Av 30. RANGE 5-500; TEMP 25; ARID 50; TROP (Hum) 40.

SURFACE WATERS (ppb): AV 0.3.

VEGETATION ASH (ppm): 20; biological response good (see discussion of Ni hyperaccumulators in Chapter 10A).

GROCHEMICAL ASSOCIATIONS: Siderophile (also chacophile); Ni, Co, Fe, Cu, Au, Ag, Pt metals, Se, Te, As and S in massive sulfide deposits (e.g., Sudbury); Ni, Co, Fe, Cu and S in veins and sulfide lenses; U, Cu, Ag, Co, Ni, As, V, Se, Au and Mo in unconformity U deposits (e.g., Key Lake, Sask.); Ni, Co, Fe, Mn and Cr in residual laterite deposits (Fig. 3-12); Mn, Ni, Cu, and Co in deep sea Mn nodules (Table 3-10).

MRIERALS: pentlandite, nickeliferous pyrrhotite, niccolite, nickeliferous laterites,
Mn nadules.

SUBSTITUTIONS IN: olivine (up to 5000 ppm), Mg-pyroxenes, amphiboles, and micas; pyrite, chalcopyrite, and other sulfides.

SOILS; OCCURRENCE: adsorbed on Fe oxides (limonite and laterites) and Mn oxides; adsorption by organic matter in soils and bogs; hydrous Ni silicates.

SECONDARY MINERALS: garnierite and other hydrated Ni silicates (including Ni-bearing serpentine).

AQUEOUS PHASE: Ionic Ni2+.

MODILITY — PRIMARY ENVIRONMENT: low; concentrates in ultramafic and basic rocks (average content 2000 ppm).

MOSILITY - SECONDARY ENVIRONMENT: good in oxidizing acidic or reducing gley .environments; immobile in alkaline (pH of hydrolysis - 6.7) or reducing hydrogen sulfide environments; often enriched in spring precipitates.

GROCHEMICAL BARRIERS: sulfide, adsorption, pH.

Nt is a PathFinder For: all types of deposits in which it occurs (e.g., massive sulfide, aetal, certain uranium deposits).

PATHFINDERS FOR NI ARE: nickel itself; Cu, Co, As, and Cr (heavy mineral surveys of soils and glacial tills using these elements are often very effective); Pt and Pd in deeply weathered lateritic terrain as in Western Australia (Table 3A-1).

COMMENTS: Ni is a good indicator in practically all types of surveys using most sampling media.

#### NIOBIUM (Nb)

IGNEOUS ROCKS (ppm): Av 20; MAFIC 20; INTER 20; FELSIC 20.

SEDIMENTARY ROCKS (ppm): SH 20; Ss < 1; Ls 0.3.

SOILS (ppm): Av 15.

VEGETATION ASH (ppm): 0.3; biological response possible, but not well documented (see Table 10A-2).

GEOCHEMICAL ASSOCIATIONS: Lithophile; Nb, Ta, Sn, W, Li, Be, Ti, Rb, Cs, U, Th, B, Zr, Hf, P, F, and rare-earths in granite and syenitic pegmatites; Nb, Ta, Na, K, Ba, Sr, Ti, Zr, U, Th, Cu, Zn, P, S, F, and rare-earths in carbonatites; Nb, Ti, Ga, Be, and Al in bauxite developed on alkalic rocks.

ORE MINERALS: pyrochlore, columbite-tantalite.

SUBSTITUTIONS IN: rutile, ilmenite, sphene, cassiterite, zircon, and biotite.

SOILS; OCCURRENCE: as heavy resistate minerals.

AQUEOUS PHASE: No is insoluble in most natural waters, however, precipitates from springs in carbonatite areas may have high contents of Nb.

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in albitic granites, pegmatites, and carbonatites.

MOBILITY - SECONDARY ENVIRONMENT: as detrital heavy minerals.

GEOCHEMICAL BARRIERS: mechanical.

NB IS A PATHFINDER POR: carbonatites; placer deposits which may also contain Au, Ti, Sn, W, rare-earths, and other elements.

PATHFINDERS FOR NB ARE: F, P, Ba, Sr, rare-earths, etc. for carbonatite occurrences; Li, Be, W, Zr, B, Rb, Cs, Mo, etc., for pegmatite occurrences; depending on the geochemical characteristics of the individual pathfinder elements, they may be either in the light or heavy fraction of soils or sediments, and some may be in solution.

COMMENTS: Tantalum always accompanies Nb in all Nb minerals (solid solution series Nb-Ta) and mineral deposits. Usually Nb predominates over Ta by a factor of 10; however, in some minerals and in some carbonatites, Ta>Nb. Ta has essentially the same geochemical characteristics as those listed above for Nb, and the same geochemical techniques used to search for Nb apply to Ta.

#### PLATINUM (Pt)

IGNEOUS ROCKS (ppm): AV 0.002; MAFIC 0.02; FELSIC 0.008.

GEOCHEMICAL ASSOCIATIONS: Noble and siderophile; Pt, Ni, Cu, Co, As, Ag, and Au, with minor Te, Bi, Sn and Sb, where Pt is a minor constituent (< 0.5 ppm Pt) in massive Ni-Cu sulfide ores containing sperrylite (Sudbury type); Pt, Ag, Au, Cr, Fe, Cu, Ni, Co and S in sulfides (Merensky Reef, South Africa; see below).

ORE MINERALS: various Pt arsenides (e.g., sperrylite), sulfides (e.g., braggite), Bitellurides (e.g., moncheite), and compounds with Sb, Sn, Hg and Fe; also native Pt. Os-Ir, etc.

SUBSTITUTIONS IN: chromite; reportedly in solid solution in pyrite, pyrrhotite, and pentlandite at Merensky Reef (Boyle 1974a).

SOILS; OCCURRENCE IN: native platinum; chromite; intergrown with heavy resistate minerals (e.g., chrome-spinel).

MOSILITY - PRIMARY ENVIRONMENT: low; concentrates in dunitic ultrabasic rocks containing Cu-Ni sulfides (typically pyrrhotite, pentlandite, chalcopyrite); associated minerals are olivine, chrome-spinel, chromite, magnetite.

MOSILITY - SECONDARY ENVIRONMENT: only as detrital grains of native platinum which form placers.

GEOCHEMICAL BARRIERS: mechanical.

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PT B A PATHFINDER FOR: Ni sulfide deposits in Western Australia by analyzing momens (see Table 3A-1).

PATHFINDERS FOR PT ARE: Ni, Cu, Cr, Co, Se, and Te; mineralogical identification of Cr-spinel, chrome-magnetite, olivine, and chromite in geologically (avorable areas with ultrabasic rocks (including serpentinites) using heavy mineral concentrates.

COMMENTS: The term "platinum metals" or "platinoids" applies to six elements: Ru. Rh. Pd. Os. Ir and Pt which are geochemically closely associated. Minerals of the Pt group may contain all six elements in varying proportions (e.g., in Alaskan placers, usually Pd>Pt). Platinum element mines in South Africa (Merensky Reef), which are among the richest in the world, contain only approximately \$ ppm (0.25 oz/ton) total platinoids.

Data are lacking for the behaviour of Pt during weathering, transport mechanisms in aqueous media, biogeochemistry, and for many other geochemical perameters. Excellent reviews of Pt geochemistry have been prepared by J. H. Crocket (in Wedepohl, 1969) and Boyle (1974a). The latter lists 14 types of deposits in which Pt group metals are concentrated; most are not economic at this time.

#### RADIUM (Ra)

ROCKS (ALL TYPES): The nuclei ratio Ra/U at equilibrium is 3.42 × 10-7; half-life of 236Ra is about 1600 years.

FACE WATERS: Av 0.1 - 1.0 picocuries/liter (pCi/l).

VEGETATION ASH (ppm): average values not available; biological response excellent (see Table 10A-1; Figs. 10A-1 and 10A-5).

GEOCHEMICAL ASSOCIATIONS: Lithophile; 234U, 234Th, 234Ra, 222Rn, 214Bi, and 344Pb in uranium deposits which are in equilibrium (Fig. 3A-12); Ra and Ba in weathering products (e.g., gossans) generally as radiobarite (Ba, Ra) SO₄; Ra, Mn, Fe in precipitates from springs; Ra and organic matter in bogs, or as thucolite. (Several other Ra isotopes are known of which 228 Ra, with a half-life of 6.7 years, has potential in exploration for Th.)

ORE MINERALS: none; if recovered (which today is for environmental as opposed to economic reasons) it is as a by-product of U or Th processing.

SUBSTITUTIONS IN: radiobarite; also in radio-calcite, radio-opal, and Mn-Fe oxides at spring deposits.

SOILS; OCCURRENCE IN: radiobarite, adsorbed on Mn-Fe oxides, or in U or Th minerals.

SECONDARY MINERALS: radiobarite, Mn-Fe oxides, and other minerals mentioned

AQUEOUS PHASE: ionic Ra2+; very soluble.

MOBILITY - PRIMARY ENVIRONMENT: high; similar to Ba.

MOBILITY - SECONDARY ENVIRONMENT: high, but mobility reduced by the geochemical barriers listed below; soluble in all types of waters (surface, ground, and lake).

GEOCHEMICAL BARRIERS: cocrystallization (with Ba in radiobarite or Ca in radiocalcite); coprecipitation (with Fe-Mn oxides); adsorption (by Fe-Mn oxides, clays and organic matter).

RA IS A PATHFINDER FOR: U and Th deposits of all types; other types of deposits containing U or Th as accessories (e.g., rare metal pegmatites, carbonatites).

COMMENTS: Modern exploration geochemists concerned with search for uranium must understand: the concepts of disequilibrium in the U series; the relationships between Ra and U, and between Ra, Rn and 314Bi; false anomalies which may result from the fractionation of Ra from its parent and daughter nuclides; geochemical barriers for Ra; limitations and pitfalls in the use of radon techniques; and other aspects of the mobility of U and its daughter nuclides in the secondary environment. These are discussed in Chapter 3A and in other parts of this book (see index).

#### RADON (Rm)

ROCKS (ALL TYPES): The nuclei ratio Rn/U at equilibrium is  $2.3 \times 10^{12}$ ; half-life of 222Rn is about 3.8 days.

SURFACE WATERS: 0-5 pCi/1 in lakes: 5-100 pCi/1 in streams: 100-1000 pCi/1 in wells and springs.

VEGETATION ASH (ppm): Average value not available; dependent upon amount of Ra in the vegetation.

GEOCHEMICAL ASSOCIATIONS: Lithophile; 222Rn is a decay product of 224Ra in the 228U series, hence, the association 222Rn and 226Ra, and also 222Rn and 214Bi (see Fig. 3A-12). Several other Rn isotopes are found in nature (20Rn in the 22Th series and 219Rn in the 235U series) but because of their very short half-lives (in seconds) they are not important in exploration.

SOILS: OCCURRENCE IN: all uranium minerals; radiobarite; soil gas; dissolved in soll waters and groundwater.

AQUEOUS PHASE: Rn gas is soluble in water.

MOBILITY - PRIMARY ENVIRONMENT: potentially high, but limited by its short half-life (3.8 days) and the emanation coefficient of radioactive minerals.

MOBILITY - SECONDARY ENVIRONMENT: potentially high; limited by its short half-life, emanation coefficient, and physical characteristics of the host formation.

GEOCHEMICAL BARRIERS: short half-life; emanation coefficient of parent Ra-containing mineral; physical characteristics (e.g., permeability) of host rock or other formations through which Rn attempts to transgress.

RN IS A PATHFINDER FOR: uranium and thorium deposits; other types of deposits containing U or Th as accessories (e.g., rare metal pegmatites, carbonatites); the value of Rn is based upon the fact that it is a gas which, in theory at least, can migrate upwards so that concealed deposits can be detected.

COMMENTS: Comments under "Radium" are applicable to radon.

#### RARE EARTH ELEMENTS (RE or REE) (see Certum)

#### SELENIUM (Se)

IGNEOUS ROCKS (ppm): AV 0.05; MAPIC 0.05; FELSIC 0.05.

SEDMENTARY ROCKS (ppm): SH 0.6; Ls 0.08.

SOILS (ppm): AV 0.2.

SURFACE WATERS (ppb): Av 0.2.

VEGETATION ASH (ppm): 1; biological response good particularly as a geobotanical indicator and as a biogeochemical sampling medium for Se-containing U ores in the western U.S.

GEOCHEMICAL ASSOCIATIONS: Chalcophile; Se, Hg, As, Sb, Ag, Cu, Zn, Cd and Pb in polymetallic sulfide ores; Cu, Ni, Se, Ag, Co, etc., in copper-pyrite ores (e.g., Sudbury); U, V, Se, Cu, Mo in sandstone U ore; Au and Ag selenide ores.

ORE MINERALS: none; by-product from refining of sulfide (primarily Cu) ores; also recovered as native Se from some sandstone-type U ores.

SUBSTITUTIONS IN: pyrite, chalcopyrite, pyrrhotite, and sphalerite (Table 2-5), and in other sulfide minerals, substituting for S.

SOILS; OCCURRENCE: adsorbed on iron oxides (gossans) and on clay minerals; native Se.

SECONDARY MINERALS: native Se; secondary selenides.

AQUEOUS PHASE: as ionic selenite (possibly as selenate); similar to sulfate in its mobility.

MOBILITY - PRIMARY ENVIRONMENT: accompanies S separated from magmas; hence may be found in sulfides from basic to hydrothermal deposits with some changes in S:Se ratio; also forms selenides at hydrothermal stages.

MOSTLITY - SECONDARY ENVIRONMENT: good in oxidizing, acid, and alkaline environments; immobile in reducing environments (similar to S); Se-bearing sulfides and selenides weather easily resulting in selenite ions.

GEOCHEMICAL BARRIERS: reducing, adsorption.

SE IS A PATHFINDER FOR: sandstone, classical vein, and unconformity types of uranium deposits; polymetallic sulfide deposits; some Au-Ag deposits; Ni sulfide deposits in Western Australia by analyzing gossans for Pt, Pd, and Se (see Table 3A-1).

COMMENTS: Se is related to S in its biological behavior and certain plants are Se accumulators whereas it is toxic to other forms of vegetation (also to cattle and other animals). Most of the successes with vegetation surveys (both geobotanical and biogeochemical) based on Se are limited, at least to this point, to the U-bearing regions of the western United States (pp. 393-395). However, Se in plants has potential in exploration for gold and other ores in which Se is present.

#### SILVER (Ag)

IGNEOUS ROCKS (ppm): Av 0.07; MAFIC 0.1; INTER 0.07; Felsic 0.04. SEDIMENTARY ROCKS (ppm): SH 0.05; BLSH < 1-5; SS < 0.01; Ls 1.

SOILS (ppm): AV 0.1.

SURPACE WATERS (ppb): AV 0.3.

VEGETATION ASH (ppm): 1; biological response of vegetation for Ag is poor (Table 10A-1) but anomalies can be detected (Tables 10-2, 10A-2).

GEOCHEMICAL ASSOCIATIONS: Chalcophile; Pb, Zn, Cd, Ag, Hg, As, Sb, Se in complex sulfides; Ag, Ni, Co, Fe, S, As, Sb, Bi (and U) in native Ag deposits containing Ni-Co arsenides (Cobalt type); U, V, Se, As, Mo, Pb, Cu, Ag, etc., in Cu-U-V "red bed" sandstone deposits; U, Cu, Ag, Co, Ni, As, V, Se, Au and Mo in unconformity vein uranium deposits (e.g., Key Lake, Sask.); Au, Ag, Te and Hg in veins; Cu, Mo, Ag (and Au) in some porphyry copper deposits.

ORE MINERALS: native silver, argentite, tetrahedrite, Ag-bearing galena.

SUBSTITUTIONS IN: galena, sphalerite, chalcopyrite (Table 2-5); other sulfides; arsenides and antimonides (particularly tetrahedrite); native copper, also in nearly all silicates but seldom exceeding 500 ppb (0.5 ppm), possibly replacing Na.

SOILS; OCCURRENCE: enriched in A (humic) horizons (Fig. 3-3); adsorbed by Mn and Fe oxides.

SECONDARY MINERALS: cerargyrite, secondary native silver.

AQUEOUS PHASE: various chloride complexes with Na and K; complex suifide, polysulfide and hydrosulfide ions; soluble organic complexes.

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in late hypogene veins and stockworks (e.g., some porphyry copper deposits); in veins with carbonates or barite (Au is usually found with quartz); forms supra-ore halos (Figs. 7-5, 7A-9).

MOBILITY — SECONDARY ENVIRONMENT: slightly mobile in oxidizing, acid and gley environments; immobile in reducing and alkaline environments; concentrated in supergene enrichment zones (p. 84); mobility reduced by precipitates (e.g., Pb) and adsorption; mobility increased by certain complexes (e.g., thiosulfate); Ag only rarely forms placers.

GEOCHEMICAL BARRIERS: sulfide; pH; adsorption (by humic materials, Fe and Mn oxides); ionic precipitates (precipitated by Pb, Cl, chromate, arsenate).

AG IS A PATHFINDER FOR: Au-Ag veins; some types of U deposits; some types of porphyry copper deposits; other types of deposits in which it occurs.

PATHPINDERS FOR AG ARE: Ni, Co, As, Sb and Bi in native Ag deposits (Cobalt type); where U occurs in native Ag veins, it (U) may be used; Hg in some types of deposits; Ag is a good indicator of its own deposits.

COMMENTS: Boyle (1974a) notes that ground and surface waters in the vicinity of Ag deposits are frequently enriched in Ag and other elements, particularly Ni, Co, U and As (Table 3-2; see also Table 3A-4 which confirms the use of Ag in certain hydrogeochemical surveys).

TANTALUM (Ta) (see Nioblum)

#### TELLURIUM (Te)

IGNBOUS ROCKS (ppm): AV 0.001; MAFIC 0.001; INTER 0.001; FELSIC 0.001.

SEDIMENTARY ROCKS (ppm): SH 0.01.

GENCHEMICAL ASSOCIATIONS: Chalcophile; Ni, Cu, Co, Te, etc., in pyrrhotite-penttandite mafic sulfide ores with chalcopyrite (e.g., Sudbury); Au-Te in sulfide-bearing veins (e.g., Cripple Creek, Colorado); Au, Ag, Te, Hg in high temperature veins; Cu, Mo, Te, S in some porphyry copper deposits (e.g., western U.S.); polymetallic sulfide deposits with Pb may contain Te.

ORE MINERALS: none; Te is a by-product of the smelting of Ni-Cu massive sulfide ores, and polymetallic ores (particularly those containing Pb).

SUBSTITUTIONS IN: pyrite (particularly of high temperature sedimentary origin);

Alphdenite; native gold and silver.

SOILS: OCCURRENCE: as stable tellurides in some environments; in highly oxidizing environments, Te may occur as native tellurium or be oxidized to TeO₂; also as tellurites and tellurates.

SECONDARY MINERALS: various rare tellurites (e.g., emmonsite) and tellurates (e.g., ferrotellurite), TeO₂ (tellurite or paratellurite), and native tellurium.

AQUEOUS PHASE: mostly as tellurite (TeO₁2-).

MOBILITY — PRIMARY ENVIRONMENT: accompanies sulfur in sulfides separated from magmas ranging from mafic to high temperature hydrothermal; forms extensive primary halos (see Fig. 7-3).

MOBILITY — SECONDARY ENVIRONMENT: very low mobility in solution; primary tellurides are very stable in most environments and may accumulate in placers with gold and other heavy minerals.

GEOCHEMICAL BARRIERS: mechanical.

TE IS A PATHFINDER FOR: Au-Te veins; polymetallic sulfide deposits (e.g., Coeur d'Alene, Idaho, Fig. 7-3); some porphyty ores (e.g., Ely, Nevada).

COMMENTS: Many aspects of the geochemistry of Te (e.g., abundances in sedimentary rocks, soils, vegetation, waters) are poorly known. Interest in Te is based on its potential in lithogeochemical surveys as it forms extensive primary halos which may permit the detection of blind ore bodies. Te may also be detected in soils developed on primary halos (see Watterson et. al., 1977, for additional information).

#### THORIUM (Tb)

IGNEOUS ROCKS (ppm): AV 10; MAFIC 2; INTER 10; FELSIC 17.

SEDIMENTARY ROCKS (ppm): SH 12; Ss 2; Ls 2.

SOILS (ppm): AV 13.

SURFACE WATERS (ppb): Av 0.1.

VEGETATION ASH (ppm): insufficient data; biological response to Th is negligible; however, associated elements may be good (particularly Ra; Figs. 10A-1 and 10A-5).

GEOCHEMICAL ASSOCIATIONS: Lithophile; in general the association K, Th and U is found throughout the magmatic crystallization sequence; the deposits and associations of Th are essentially the same as those mentioned for cerium (as representative of the rare-earths) and uranium; see entries for Cerium and Uranium.

ORE MINERALS: Chiefly thorium-rich (up to 18% Th) monazite; the polymorphs thorite and huttonite (ThSiO₄), and thorianite (ThO₂).

SUBSTITUTIONS IN: monazite, zircon, sphene, allanite, xenotime, uraninite.

SOILS; OCCURRENCE IN: primarily resistate, clastic and transported minerals and rock fragments; Th (up to 50 ppm) in laterities is due in part to Th in zircon and in part to possible adsorption by aluminum hydroxides.

SECONDARY MINERALS: none.

**AQUEOUS PHASE: none.** 

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in late stage granites and pegmatites; highly concentrated in some alkalic rocks, including carbonatites.

MOBILITY - SECONDARY ENVIRONMENT: only as clastic and detrital mineral phases in the heavy fractions of soils, sediments, glacial debris, etc.; forms placers (e.g., Thrich monazite).

GEOCHEMICAL BARRIERS: mechanical (placers); (adsorption by clays and aluminum hydroxides is minor).

TH IS A PATHFINDER FOR: deposits containing the rare-earths, Nb and Ta (e.g., monazite and other minerals in carbonatites or pegmatites); some U deposits in hydrothermal veins (e.g., Bokan Mtn., Alaska); U, Au, Th, RE, etc., in placers.

PATHFINDERS FOR TH ARE: rare-earth elements, Nb, Ta, and F for carbonatite occurrences; U, RE, Nb, Ta, Zr, Ti, etc., for placer occurrences.

COMMENTS: The may be detected by gamma radioactivity from the isotope ²⁰⁷Il (which has a different energy level than that of ²¹⁴Bi); caution must be exercised to ensure that the source of the gamma radiation (whether it is from a decay product of U or Th, or both) is properly interpreted.

#### TIN (Sa)

IGNBOUS ROCKS (ppm): Av 2; MAFIC 1; INTER 2; FELSIC 3.

SEDIMENTARY ROCKS (ppm): SH 4; SS < 1; Ls 4.

SOILS (ppm): AV 10. TEMP 2-10; ARID 3-50; TROP (HUM) 3-20.

SURFACE WATERS (ppb): insufficient data.

VEGETATION ASH (ppm): 5; biological response to Sn is apparently satisfactory based on data in Table 10A-2 but specific details are lacking.

GEOCHEMICAL ASSOCIATIONS: Lithophile; Sn, W, Nb, Ta, Be, B, Li, Rb, Cs, and reresenths in pegmatites; Sn, W, B, F, Be, etc., in veins and greisens (gangue minerals include quartz, fluorite, Li-micas, topaz and tourmaline); Sn, B, F (and As) in cassiterite pipes (e.g., Australia and South Africa).

ORE MINERALS: cassiterite, stannite.

SUBSTITUTIONS IN: biotite, muscovite, sphene, rutile, tourmaline, magnetite, amphiboles.

SOILS; OCCURRENCE IN: residual cassiterite; possibly some Sn in aluminum oxides. SECONDARY MINERALS: none.

AQUEOUS PHASE: possibly as ionic Sn²⁺ in very acidic waters (pH of hydrolysis = 2.0).

MOBILITY - PRIMARY ENVIRONMENT: high; enriched in high temperature pneumatolytic and hydrothermal deposits, granites, permatites, and greisens.

*OBILITY — SECONDARY ENVIRONMENT: effectively immobile in solution; mainly as detrital cassiterite which forms placers.

GEOCHEMICAL BARRIERS: mechanical for cassiterite; pH for Sn2+.

SN IS A PATHFINDER POR: rare metal pegmatite and greisen deposits by determining cassiterite in the heavy fractions of soils, sediments (in streams, lakes or oceans), or in glacial materials.

PATHFINDERS FOR SN ARE: Sn is a good indicator of its own deposits. High Sn contents in pegmatitic muscovites indicate favorable pegmatites. High Sn in granites indicate potential Sn-bearing plutons (see Tables 7-2 and 2A-8). Cassiterite in heavy fractions of soils, sediments or glacial material is particularly effective in locating primary tin lodes and their derived placers. Fe-Mn precipitates at spring orifices may contain Sn, W, Li or other elements associated with Sn deposits.

COMMENTS: See Boyle (1974a) for additional information.

#### TUNGSTEN (W)

IGNEOUS ROCKS (ppm): Av 1.5; MAFIC 1; INTER 2; FELSIC 2.

SEDIMENTARY ROCKS (ppm): SH 2; SS 1.6; LS 0.5.

SOILS (ppm): insufficient data.
SURFACE WATERS (ppb): AV 0.03.

VEGETATION ASH (ppm): average concentration value not available; biological response reasonably good (Table 10A-1); probably best for scheelite ores in soils with low pH in order to mobilize the W (see Quin et al., 1974).

GEOCHEMICAL ASSOCIATIONS: Lithophile; W, Mo, Sn, Cu, As, Nb, Ta, Bi, Li, B, F and rare earths in pegmatites and aplites with principal W mineral being wolframite; W, Mo, Bi, Cu, Pb, Zn, S, As, Au, Ag, B and F in skarn deposits with scheelite as the principal W mineral.

ORE MINERALS: scheelite, wolframite.

SUBSTITUTIONS IN: muscovite, Nb-Ta minerals (up to 1% W), Mn oxides (particularly near hot springs); in powellite and wulfenite substituting for Mo.

SOILS; OCCURRENCE IN: resistate scheelite and wolframite, and possibly the secondary minerals listed below.

SECONDARY MINERALS: tungstite (WO₃·H₂O) and ferritungstite under conditions of acid weathering.

AQUEOUS PHASE: as tungstate in sikaline waters (see below), polytungstates and complexes (but not ionic).

MOBILITY - PRIMARY ENVIRONMENT: high; concentrates in late crystallizing phases such as granites, pegmatites, and high temperature hydrothermal veins; forms sub-ore halos (Fig. 7A-6).

MOBILITY - SECONDARY ENVIRONMENT: slightly mobile in alkaline solutions; primarily as detrital grains of wolframite and scheelite in heavy fractions.

GEOCHEMICAL BARRIERS: pH (slightly soluble only in alkaline waters); adsorption by Mn in sediments, soils, spring precipitates and some bogs (which contain Mn); mechanical for placers.

W IS A PATHFINDER FOR: non-pegmatitic beryllium, and beryllium-fluorite deposits (Table 3A-4).

PATHFINDERS FOR W ARE: W is an excellent indicator of its own deposits particularly by obtaining scheelite and wolframite in the heavy fractions of eluvium near W deposits, in soils or stream sediments (scheelite fluoresces in ultraviolet light whereas wolframite does not). B, F, As, Li, and Cu in some districts.

COMMENTS: Boyle (1974a) list 11 different types of W occurrences, including the alkaline brines at Searles Lake, California, which contain 70 ppm WO₃.

#### URANIUM (U)

IGNEOUS ROCKS (ppm): Av 2.7; MAFIC 0.6; INTER 3; FELSIC 4.8. SEDIMENTARY ROCKS (ppm): SH 4; BLSH 3-1250; SS 0.45-3.2; Ls 2.

Soils (ppm): Av 1.

SURFACE WATERS (ppb): Av 0.4.

VEGETATION ASH (ppm): 0.5; poor biological response (Table 10A-1) but associated elements such as Ra, Mo and Se may be useful.

GROCHEMICAL ASSOCIATIONS: Lithophile; U, Th. rare-earths, P, F, Zr, Ti, Mo, Bi, Cu, Ag, Zn, etc., depending on the type of igneous association (e.g., pegmatite, carbonatite); U, Cu, V, Se, Mo, C in sandstone type; U-Au in placers; see below under "Pathfinders" for additional associations.

ORE MINERALS: uraninite, brannerite, carnotite.

SUBSTITUTIONS IN: zircon, apatite (including phosphorites), allanite, niobate-tantalates (e.g., euxenite), monazite (Table 2A-5).

ions; occurrence in: resistate, clastic and transported minerals and rock fragments; adsorbed on organic matter, clays, and iron oxides.

BCONDARY MINERALS: phosphates, vanadates, carbonates; also uraninite.

Quantum PHASE: uranyl carbonate and phosphate complexes (Figs. 3A-10, 3A-11).

મહે .TY – PRIMARY ENVIRONMENT: highly mobile; concentrates in late phases (granites, hydrothermal veins).

**MODILITY** — SECONDARY ENVIRONMENT: highly mobile in the oxidizing environment, especially alkaline (Figs. 3A-10, 3A-11).

JECCHEMICAL BARRIERS: reduction (Eh); adsorption; special ion precipitates (e.g., variables such as carnotite).

J B A PATHFINDER FOR: uranium deposits; it has potential for Au-U placers, certain Ag-Au voins, and carbonatites.

'ATHPINDERS FOR U ARE: Depending upon type of deposit: (a) sandstone or roll-front type: Mo, Se, V, Cu, C; (b) classical vein (e.g., Beaverlodge, Sask.): Cu, Ag, Co, V, Ni, As, Au, Mo, Bi, Se; (c) unconformity vein (e.g., Key Lake, Sask.): Cu, Ag, Co, Ni, As, V, Se, Mo, Au; (d) pegmatite: Th, Mo, Nb, Ti, rare-earths; (e) carbonatite: Nb, Th, Cu, F, P, Ti, Zr, rare-earths; (f) placer (e.g., Elliot Lake, Ont.): Th, Ti, Au, Zr, rare-earths. In addition, Rn, He and Ra for all types of uranium deposits.

comments: All modern exploration geochemists must understand the factors ing the mobility of uranium and its daughter products (e.g., Rn, Ra) in the secondary environment, complexing, disequilibrium, and other topics discussed throughout this book, particularly in Chapter 3A (but see additional entries in the Index). Also, see entries under Radium and Radon in this Appendix.

#### VANADIUM (V)

JNBOUS ROCKS (ppm): AV 135; MAFIC 250; INTER 100; FELSIC 20. EDIMENTARY ROCKS (ppm): SH 130; BLSH 150-700; SS 20; LS 15.

ORS (ppm): AV 80. RANGE 20-500; TEMP 10-400; ARID 10-300; TROP (HUM) 10-300.

SURFACE WATERS (ppb): AV 0.9.

VEGETATION ASH (ppm): 60; geobotanical indicators of V are known (Table 10-2) but the overall biological response for exploration purposes are poorly documented.

GEOCHEMICAL ASSOCIATIONS: Siderophile and lithophile; V, Ti, Fe and P in vanadiferous magnetite; V, Cu, Pb, Zn, Mo, Ag, Au and As in polymetallic sulfide deposits; U, V, Se, Mo, Cu, K, Ca and C in sandstone-type U ores; P, U, V, F, Se, As, etc., in phosphorites and black shales; V, Fe, Mn and P in certain V-rich sedimentary iron ores; V, S, C, Ni, Fe and Ca in deposits of asphalt or other solid hydrocarbons (e.g., Minas Ragra, Peru); V is a common constituent of petroleum (generally from 5-50 ppm) from which it may be economically recovered; V may be high in the ash of some coals; and V and other elements in Mn and Fe oxides.

ORE MINERALS: principally vanadiferous (up to 0.5% V) magnetite; V-containing uranium minerals (e.g., carnotite); patronite (VS₄) is one of only two known vanadium sulfides and is mined in Peru.

SUBSTITUTIONS IN: magnetite, sphene, rutile, muscovite (var. roscoelite), biotite, apatite (in iron ores), amphiboles; the silicates release V upon weathering.

Soils: OCCURRENCE IN: within resistates (e.g., magnetite, sphene), or in decomposing mafic minerals; adsorbed or coprecipitated with clays (e.g., laterites); in Fe-Mn oxides.

SECONDARY MINERALS: many secondary vanadates (e.g., vanadinite, descloizite, carnotite, tyuyamunite); also V oxides (e.g., montroseite) and other mineralogical types.

AQUEOUS PHASE: as various soluble vanadates, e.g. (H₂VO₄)-.

MOBILITY - PRIMARY ENVIRONMENT: low; concentrates in the early-formed rocks and minerals (e.g., magnetite, mafics) as a trace-minor constituent replacing Fe; vanadium forms no primary magmatic minerals.

MOBILITY - SECONDARY ENVIRONMENT: highly mobile in oxidizing, acid-alkaline waters; immobile in reducing environments (Fig. 3-19, Table 3A-3); spring precipitates often enriched in V; resistates (e.g., V-magnetites) form placers.

GEOCHEMICAL BARRIERS: reducing; adsorption; mechanical (placers).

V IS A PATHFINDER POR: sandstone, classical vein, and unconformity vein types of uranium deposits.

PATHFINDERS FOR V ARE: V is a good indicator of its own deposits and most types of surveys (e.g., soils, sediments) work well; analysis of magnetites in heavy mineral surveys for V may lead to vanadiferous magnetite deposits.

COMMENTS: Vanadium is a widely dispersed, relatively abundant element (more abundant than Cu, Pb, Zn or Ni; Table 2A-1). In magmas V occurs as V³⁺ and replaces Fe³⁺ in magnetite, malic minerals, and micas (siderophile association); in the secondary environment (vanadates; lithophile association) it occurs as V³⁺. V may also occur in the tetravalent state, such as VO²⁺ complexes in soil organic matter. Along with Fe, Mn, S and U (and to a lesser extent, Mo and Se), vanadium is one of the few elements whose variable valence state is of importance in exploration geochemistry.

#### ZINC (Za)

IGNEOUS ROCKS: (ppm): Av 70; MAFIC 100; INTER 60; FELSIC 40.

SEDIMENTARY ROCKS (ppm): SH 100; BLSH < 300-1000; Ss 16; Ls 25.

Soils (ppm): Av 50. RANGE 10-300; TEMP 10-600; ARID 10-900; TROP (HUM) 10-400.

SURFACE WATERS (ppb): AV 20.

VEGETATION ASH (ppm): 900; biological response fair to poor (Zn is a "difficult" element; see p. 407); high Zn can produce barren areas (Fig. 10A-2) as a result of its toxicity to vegetation even though it is an essential nutrient in small amounts.

GEOCHEMICAL ASSOCIATIONS: Chalcophile; Zn, Cd in essentially all occurrences; Zn, Cd, Pb, Ba, F in Mississippi Valley type deposits; Zn, Pb, Mn, Ba, Fe in stratiform (volcanogenic) deposits; Zn, Pb, Fe, Cu, Ag, Ba, Te, etc., in veins and massive sulfide deposits; Zn, Pb, Cu, Ag, B, Mo, W, Be in skarns; Mn, Ni, Cu, Co, Zn in heap-sea nodules; Cu, Mo, Re, Fe, Au, Ag, Zn in some porphyry copper deposits (Fig. 7A-4); Cu, Pb, Zn in copper shales.

ORE MINERALS: sphalerite (which contains numerous trace elements such as Cd, Se, . Ma, Ag, Cu, Ga, Hg, etc.; see Table 2-5); sphalerite is easily weathered.

SUSTITUTIONS IN: biotite and amphibole (in acid and intermediate rocks replacing Fe²⁺ and Mg²⁺; these minerals are easily weathered); magnetite (in mafic rocks; stable).

SCILS: OCCURRENCE IN: Fe-Mn oxides (adsorbed and coprecipitated); clays and organic matter (adsorbed); in some secondary Zn minerals.

SECONDARY MINERALS: smithsonite (ZnCO₃); hemimorphite (Zn₄Si₂O₂(OH)₂·H₂O); hydrozincite (Zn₅(CO₃)₂(OH)₄); willemite (ZnSiO₄).

AQUEOUS PHASE: ionic Zn¹⁺; soluble organo-metallic complexes; some Zn may be "temporarily" incorporated in floating organisms (e.g., algae) or adsorbed on suspended matter:

MOSILITY — PRIMARY ENVIRONMENT: in most igneous rocks Zn substitutes in mineral structures (e.g., magnetite, biotite, amphibole); Zn ore deposits in igneous rocks a smally found associated with felsic rocks and hydrothermal veins; transport probably as chloride and bisulfide complexes.

MOSILITY — SECONDARY ENVIRONMENT: high in oxidizing acidic and neutral waters (pH of hydrolysis — 7.0; Table 3-6), hence low mobility in carbonate-rock terrain; high in reducing gley environment (Table 3A-3); immobile in sulfide environment; mobility in waters may be greatly reduced by adsorption or coprecipitation on Fe-Mn oxides (in soils, stream sediments, spring precipitates), and by adsorption on organic matter.

GEOCHEMICAL BARRIERS: pH; reducing hydrogen sulfide; adsorption (on clays, Fe-Ma oxides, organic matter); coprecipitation (on Fe-Ma oxides); precipitated by high abundances of carbonate and phosphate in waters. ZN IS A PATHFINDER FOR: Pb deposits; Pb-Ag deposits; some fluorite deposits; most polymetallic sulfide deposits; skarn deposits; porphyry copper deposits; numerous other deposits (see Table 3A-4).

PATHFINDERS FOR ZN ARE: Hg in some vein and massive sulfide deposits; F in some carbonate-hosted Zn deposits; F in some skarn deposits; Pb in soils, glacial materials, and other sampling media (usually except waters) where Zn and Cd have been leached from sphalerite-galena deposits; Mn in stratiform (exhalative) deposits (Fig. 7A-2); Zn is an excellent indicator of its own deposits.

COMMENTS: Zn is the most commonly determined element in geochemical exploration because: (1) it is easily determined by several analytical methods to sufficiently low abundances; (2) it is mobile in most geochemical environments (important exceptions include alkaline, and reducing hydrogen sulfide environments); (3) it forms extensive halos in soils, sediments, glacial materials, most types of waters, bog materials, etc.; (4) it is a common constituent of many different types of deposits and, therefore, it is a good pathfinder (Table 3A-4).

Zn (up to 0.1%) may be found in some phosphate fertilizers (see pp. 196 and 204 for other examples of Zn contamination and faise anomalies). Wedepohi (1969-1974; Chapter 30) prepared an outstanding compilation on the geochemical characteristics of Zn.

# Geochemical Exploration Methods For Mineral Deposits

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Moscow

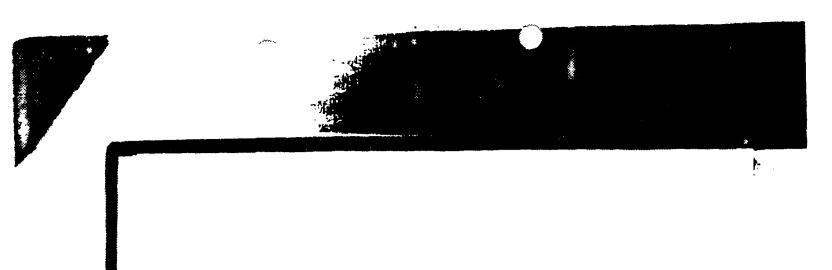
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of the lithosphere ements, including ning 0.5% is actracted as the contents in the distribution of the matter crustal in presently availations is 1.0% or resent in amounts.

of the various rock osition of the graiformation of the graiformation on the en the calculated constituent rocks.
If and that of graintimate relationcdimentary rocks of the processes of the processes of nitic layer in the average composind a granodioritic ither. Table 2 lists

1% = 1000ppm 10-4% = 1ppm

Table 3 Average contents of chemical elements in the lithosphere and in its constituent rocks (weight percent)

Atomic	l.iemeni	Continental hithosphere lexcluding sedi meniary cover?	Ciranitic shell	Granite	Granodiorile	Interniediale rocks	Basic rocks	Ultra- basic	Schisi	Sedimentary rocks Sandstone	Carbonate rocks
1	Hydrogen	0,10	0,10	0,06	0,09	0.11	0,12	-	0,40	0,25	0,09
2	Helium				6-10	-bcm1 per gram of	rock weight				
3	Lithium	2.0.10-3	3,0.10-3	3,8-10-3	3,0.10-3	2,5-10-3	1,5 10-4	0,2.10-3	6,6-10-3	1,5-10-3	0,5.10-3
4	Beryllium	1,5-10-4	2,5⋅10-4	3,5 10-4	2,5⋅10-4	1,8-10-4	0,4-10-4	0.2 10-4	3,0-10-1	0,n 10-4	0,n·10-4
5	Boron	0.7 10-3	1,0 10-3	1,5-10-3	1,2-10-	0,9 10-3	0,5-10-	0,3-10-3	10-10-3	3,5 10-3	2,0-10-3
6	Carbon	1,7 10-2	3,0 10-2	3,0-10-1	3,0.10-3	3,0.10-3	2,0-10-1	1,0.10-2	1,2	1,3	11,0
7	Nitrogen	2,0 10-3	2,6 10-3	2,7.10-3	2,0 10-4	2,0-10-3	3,5-10-3	1,0.10-3	54,5 - 10-2	13,5 - 10-3	0,7-10-3
8	Oxygen	46,6	48,1	48,7	48,0	47,0	44,5	43,7	49,0	51.5	49.2
9	Fluorine	6,0.10-1	7.2-10-3	8,3-10-8	6.3-10-1	5,0 10-	4.0.10-9	1,0-10-1	7,4-10-2	2.7-10-2	3,3-10-1
10	Neon				7,7.10	-e cm, bet ftrein	of rack weight				
11	Sodium	2,3	2.2	2,66	2,78	2.60	1,90	0,18	0,98	0,92	0,25
12	Magnesium	2,4	1,2	0,33	1,10	2,20	4,50	20,50	1,50	0,73	4,60
13	Aluminum	8,1	8.0	7,40	8,60	8,90	8,50	2,40	8,65	2,90	0,96
14	Silicon	27,7	30,9	34,0	30,5	27,5	23,0	20.0	27.5	34,7	3,4
15	Phosphorus	0,10	0,08	0,06	0,11	0,15	0,15	0,05	0.07	0.04	0,05
16	Sulfur	0,03	0,04	0,04	0,04	0,04	0,03	0,01	0,24	0.02	0,12
17	Chlorine	1.0 10-1	1,7 10-2	2.0 10-1	1,3-10-*	1,0-10-2	0.6.10-8	0.5 10-2	1.80-10-	· 0.1 10-2	ii ,5 - 10=
18	Argon				2,2.10	0→ cm, bet Braw	of rock weight				
19	Potassium	1,8	2,70	3,50	2,52	1,50	0,70	. 0,05	2,70	1,32	0,28
20	Calcium	4,3	2,5	1,12	2,40	4,60	7,30	3,40	2,00	2,67	32,5
21	Scandium	2.4 10-3	1,1 10-3	0,7-10-3	1,4-10-3	2,0 10-3	3,0.10-3	1,5-16-3	1,3-10-	0,1 10-	0.1 10-
22	Titanium	0.6	0,33	0,17	0,38	0,60	0,80	0.35	0.38	0.30	0,12

SCH DC	Elemeni	Continental lithosphere (excluding sedi- mentary cover)	Granutic shell	Granite	Granodionie	Intermediate rocks	Basic rocks	Ultra- basic	Schut	Sedimentary rocks. Sendmone	Carbonauc rocks
3	Vanadium	1.9-10-	7.6-10-	4.4.10-	8.8-10-3			<del> </del>		<u> </u> 	<u> </u>
4	Chromium	1,2.10	0.34 - 10-	0.1.10-	1	15-10-4	25.10-	4,0.10-	13 ⋅ 10 →	2.0.10-	2,0.10
5	Manganese	0.09	0.07		0,22.10-	0,55-10-	1,7-10-2	16,0-10-	0,9-10-	0.35-10-4	0.11-10
5	Iron	5.7		0,04	0.07	0,12	0,12	0.10	0.08	0.04	0,04
,	Cobalt	· I	3,6	1,83	3,30	5,50	8,40	8.70	4.80	2.80	0,85
8	Nickel	3,4.10-3	7,3⋅10-4	1,0.10⊸	7,0⋅10→	9,0 10-4	48 - 10⊸	150 - 10-4	19-10-4	0,3.10~	0.1-10-
· )		9,5.10-	2,6.10-	0,45 10-3	1,5-10-	5,0-10⊸	13-10→	200 - 10-3	6.8 10-		0.2-10-
	Copper	6,5.10-	2,2-10→	1,0-10-3	2,6:10-	4,0-10-	8,7-10-	1,0.10-	4.5-10-	0,1.10-3	-,
	Zinc	8,7.10-3	5,1-10-3	3,9-10-	5,6-10-	7,5-10~	10,5 10-3	5,0.10~	9.5-10-4		• •
۱	Gallium	1,7-10-3	1,9⋅10-	2,0 10~	2,0.10-3	1.7.10-	1,7-10-3	0,15 10-		1,6-10-	•
	Germanium	1,3 10-4	1,3⋅10-4	1,3-10-4	1,3-10-4	1.3-10-4	1,3-10-4	!	1,9.10-	1,2.10-	•
3	Arsenic	1.9.10→	1,6-10-	1,5-10-4	1.9.10→	2.0.10-4	2,0.10	1,5 10-4	1,6-10-4	0,8-10-4	•
١ ا	Selenium	1,0-10→	1,4-10-4	1.4-10-	1.4-10-4	1.4-10-4	1	1,0.10-4	13,0 - 10⊸	1.0.10→	1,0-10-
5	Bromine	2,0.10→	2,2⋅10-4	1.3.10→	4.0.10→	.,	1,3.10-	0,5.10-2	5,0.10~	0.5-10-	0,8-10-
5	Krypton			1,0 10		4,5-10-4	3,6-10-4	1.0.10-4	4.0-10-4	1,0.10-4	6.2-10-
_ ,	Rubidium	9.0-10-	18-10-6	01 10-1	4,2.10		of rack weight				
. 1	Strontium	3.8-10-4		21 -10-	16-10-	11 - 10-6	5,0.10-	0,5.10	14-10-4	6,0.10-	0.3.10
- 1	Yttrium	•- •-	2,3.10-4	1,1-10-	4,4-10-	4,5-10-	4,7-10-	0,1-10-4	3.0 10-1	0,2.10-	•
	Zirconium	2,6 10-2	3,6 10-3	4,0.10-3	3,4-10-	2,9 10-	2,1-10-3	n · 10→	2,6-10-	4.0.10-3	•
1	Niobium	1,3.10-	1,7 10-	1.8-10-	1,6-10-	1,4-10-	1,1-10-1	0,45-10-	i I	2,2.10-2	•
. 1		1,9 10-	2.0 10-3	2,1-10-	2,0-10-	2,0-10-	1.9.10-	1.6.10-	1.1.10~	l l	•
1	Molybdenum	1,3-10-4	1,3-10→	1,3⋅10⊸	1,2-10-4	1,1-10→	1.5.10~4	0.3-10-4	'	I	0,3 10-
- 1	Techneuum	-	-	-	_	· <b>-</b>	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	5,0 10	2,6⋅10→	0,2.10	0,4.10
- 1	Ruthenium		Data not	Available						i	
١ ١	Rhodium		Data not	available							

#### Table 3 (continued)

Atomic	Elemeni	Continental lithosphere (excluding sodi- mentary cover)	Granitic shell	Granite	Granodionie	intermediate rocks	Basic rocks	Ultra- basic	Schau	Sedimentary rocks. Sandmone	Carbonate rocks
47	Palladium Silver	n · 10 →	n · 10 ⁻⁴ 4,8 · 10 ⁻⁴	n · 10 ⁻⁶ 3,7 · 10 ⁻⁴	n · 10 ⁻⁴ 5, 1 · 10 ⁻⁴	я-10 ⁻⁴ 7,0-10 ⁻⁴	2,0·10 ⁻⁷ 11·10 ⁻⁴	5,0·10 ⁻⁷ 6,0·10 ⁻⁴	Data no:	available n · 10~4	n · 10 ⁻⁴

		ر ند ټې ر		-1 10				0,0 10	1 11 10	0,0 10	U.J 10*****
	Strontium	3,8 10-1	2,3-10-1	1,1-10-	4,4-10-4	4.5-10-	4.7 10-	0,1 10-	1		6, I 10
39	Yttrium	2,6 10-3	3,6-10-3	4,0-10-	3,4.10-	2,9:10-8	2,1-10-3	n · 10-4	2,6.10-	4,0-10-3	3,0 10-
40	Zirconium	1,3-10-1	1,7-10-3	1,8-10⊸	1,6.10-	1,4-10-4	1,1-10-	0,45-10-1	1,6-10-	2,2-10-1	0,2-10-1
41	Niobium	1,9-10-	2,0-10-	2,1.10-	2,0.10~	2,0-10-	1,9-10-	1,6-10>	1,1-10-	n · 10−3	0,3-10-4
42	Molybdenum	1,3-10-4	1,3 10~	1,3-10-4	1,2-10-4	1,1.10~	1,5-10→	0,3-10-4	2,6-10	0,2-10-4	0,4-10-4
43	Technetium	_	_ '	_	-	-	i				
44	Ruthenium		Data noi	i available	1				1		
45	Rhodium		Data not	available	1	1					1
	l .	Į.	l .		1	Į	į	ļ	1	1	1

Table	3	(continued)

											(continued)
Atomic	Elemeni	Continental lithosphere (excluding sedi mentary cover)	Granitic shelf	Granile	Granodionie	Întermediate rocks	Basic rocks	Ultra- base	Schoot	Sedimentary rocks Sandstone	Carbonate rocks
46	Palladium	n · 10-7	n · 10 ⁻⁴	n · 10-6	n · 10−4	n · 10 ⁻⁷	2.0.10-7	5,0.10-7	Data not	available	
47	Silver	9,0 ⋅ 10→	4,8⋅10→	3,7⋅10→	5,1⋅10→	7,0⋅10→	11 - 10-4	6,0.10-	7,0-10→	n · 10→	n · 10→
48	Cadmium	1,9-10-4	1.5-10-3	1,3⋅10→	1.6.10-3	1,8⋅10-	2,2.10-	0,1.10-3	3,0.10-	0,n·10-1	0,4.10~
49	Indium	2,3-10-3	2.5-10-3	2,6-10-	2,4.10	2,2.10	2,2.10-	0,1.10~	1,0.10-	0,n·10-3	0,n·10-4
50	Tin	1,9⋅10-	2,7.10-4	3,0-10-4	2,5.10-4	1,6⋅10→	1,5-10-4	0,5⋅10→	6,0.10-	0,#-10-4	0,n·10-4
51	Antimony	2,0 ⋅ 10→	2,0-10-1	2,0.10→	2,0.10	2,0.10-	2,0.10-	1,0.10-4	15.10~	0,n-10-4	2,0.10~
52	Tellurium	1,0-10-7	1,0-10-7	1,0-10-7	1,0-10-7	1,0.10-7	1,0-10-	0,4.10-7	10-10-7	Data not	available
53	lodine	5·10-4	د−10 - 5	5 - 10-7	5-10-7	5.10-7	5-10-4	5-10-3	2,2.10~4	1,7.10-4	1,2.10-
54	Xenon				3,4.10	-10 cm, bet Etaw	of rock weight				<del></del>
55	Cesium	2.0 10	3,8 10-4	5,0.10-4	2,0.10-4	1,5-10-4	1,1.10-4	n · 10→	5,0-10-4	I n · 10→	n · 10→
56	Barium	4,5-10-	6,8-10-8	8,4-10-8	4.5-10-4	3,8-10-	3,3-10-4	0,4-10-4	5,8-10-	n · 10→	1,0-10-
57	Lanthanum	2,5.10-	4,6-10-3	5,5-10-	4.0-10-	3,0-10-3	1,5-10-	n · 10−3	9,2-10-	3,0.10-	n · 10→
58	Cerium	6,0.10-3	8,3-10-3	9,2-10-3	8,0-10-	6,5.10~	4,8-10-	n · 10−3	5,9-10-	9,2-10-	1,2-10-
59	Praseodymium	5,7 10-4	7,9-10-4	8,8-10⊸	7,5.10-4	6,2⋅10-4	4,6-10-4	n · 10~4	5,6-10-	8,8-10-	1,1-10-4
60	Neodymium	2,4 - 10-3	3,3-10-3	3,7-10-	3,2-10-	2,7.10-	2,0.10-	n · 10→	2,4-10-	3,7-10-	4,7-10-
61	Promethium	-	<u> </u>	_	_		_	_	-	_	_
62	Samarium	6,5-10-4	9,0⋅10⊸	10,0-10-4	8,5-10-4	7,5⋅10~4	5,3-10-4	n · 10->	6,4-10	1,0.10~	1,3.10-
63	Europium	1,0-10-4	1,4-10-4	1,6-10-4	1,4-10-4	1,2-10-4	0,8-10-4	n · 10-3	1,0.10	1,6⋅10→	0,2.10
64	Gadolinium	6,5-10-4	9,0-10-3	10,0-10→	8.5-10-4	7,5⋅10-4	5,3⋅10→	n·10~	6,4-10~	1,0.10-	1,3-10→
65	Terbium	1,0.10-4	1,4-10-4	1,6-10-4	1,4-10-4	1,2-10-4	0,8-10-4	n · 10-3	1,0-10	1,6-10-	0,2-10-4
66	Dysprosium	4,6-10-4	6.5-10-4	7,2-10-4	6,1-10-4	5,2 10	3,8-10-4	n · 10→	4,6-10-	7,2 10	0,9 10-
67	Holmium	1,3-10-	1,8-10-4	2,0 10	1,8-10-4	1,5-10-4	1,1-10-4	n · 10→	1,2.10	2,0.10-	0,3-10-4
68	Erbium	2,6-10-4	3,6-10-4	4,0 10-4	3,2 10-4	2.8 10-4	2,1-10-4	n · 10→	2.5 10	4.0-10-4	0.5 10-

Atomic	£ icmeni	Continental lithosphere (excluding sedi- mentary cover)	Granitic shell	Granuc	Granodiorite	Insermediate rocks	Basic rocks	Ultra- bassc	Schut	Sedimentary rocks Sandstone	Carbonate rocks
69	Thulium	0,2.10-4	0,3-10-	0,3⋅10→	0,3-10-	0,2.10-4	0,2-10-4	n · 10→	0,2.10	0,3-10~	0,4-10-3
70	Ytterbium	2,6.10~4	3,6-10~	4,0.10-4	3.2.10	2,8-10-4	2,1-10-4	n·10 ⁶	2,6-10-	4.0.10-4	0.5 10-4
71	Lutecium	0,8-10-4	1,1-10-4	1,2-10-4	1,0-10-4	0,8.10~4	0,6-10-4	n · 10-4	0,7.10	1,2.10	0,2-10-4
72	Hafnium	2,6-10~	3,5.10~	3,9.10-4	3,2-10-4	2,8.10-4	2,2.10-4	0,5.10-4	2,8-10~4	3,9.10-4	0,3.10-4
73	Tantalum	1,0-10-	2,1-10-4	2,5-10-4	1,8-10-4	1,2.10-4	0,5.10	0,2-10-	0,8-10-	n-10-4	n · 10→
74	Tungsten	1,1-10-	1,9 10-4	2,2.10-4	1.7.10-3	1,2-10-4	0,7⋅10⊸	0,1-10-4	1,8-10-4	1,6-10~	0.6-10-
75	Rhenium	7,0-10-	7,0 10→	6,7⋅10→	1 -	_	7,1 ⋅ 10→	-	_	_	_
76	Osmium	-	Data not	available	-	-		_	-	_	_
77	lridium	2,0-10-	1,5-10→	1,0.10-	_		2,2.10-	_	-	-	<b>-</b>
78	Platinum	- 1	Data not	available	_	_	1,0⋅10→	2,0.10	_	-	_
79	Gold	1.7.10-7	1,2.10-7	0,8.10-7	1,2.10~7	2,8-10-7	3,6-10-7	6,0-10-7	n-10~	n-10-7	n · 10-7
80	Mercury	4,6⋅10→	6,6⋅10⊸	6,7-10→	6,7-10	7,5-10	6,5-10	6,4-10-	6,6-10-	7.4-10-	4.5-10-
61	Thallium	0,7-10-	1,8-10⊸	2,3-10-	1,5.10~	1,0-10-4	0,2.10-4	0,6⋅10→	1,4-10-4	0.8 10-	a · 10 ⁻⁴
82	Lead	0.9-10-	1.6-10-	1.9-10-	1,5-10-	1,2-10-	0,6-10-	0.1-10-	2.0-10-	0.7-10-	0.9.10-3
83	Bismuth	0,8-10-	1,0-10-	1,0-10-	1,0.10-4	0,8-10-	0.7-10	0,1-10-	l .	available	_
84	Polonium	] -	-	_	_	_	<b> </b>	_	_	ı —	_
85	Astatine	_	-	-	_	_	-	_	_	_	
86	Radon		Data no	avaijabje		}	]		Ì		
87	Francium		_	l –	-	_	1 -	_	_	_	_
88	Radium	[	Data not	available					1	}	
89	Actinium	_	_	-		-	_		_	_	_
90	Thorium	7,3-10-4	1,4-10-	1,7-10-	1,2.10-	8,5-10-4	4.0-10-4	4.0.10-7	1,2-10-	1.7-10-	1.7.10-
91	Protectinium	-	-		_	-	1,0-10-4	1.0-10-7	L	4.5-10-	
92	Uranium	1,5-10-	2,6⋅10→	3,0-10-4	2,5-10-4	2,0.10-4	_	_	_	_	_

T. Acmophil	(III. Noble	11. Sulfoph	1. Oxyphile		tion with	smaller n	they form	froun in	It follo	Table	XI	×	×	×	VIII	VII	<b>≤</b>	<	7	Ξ	=	-	Decade g a g ≥ p ≥	Table 4. [	irace elem	economic	icss than
	koph(1e)	tie elisabatie	ng, Ca. Na.	Major (A.	iron. ar	umber c	n the ch	studes of	ws from	5 presen	ē	0	ē	ō	Ī	ទុ	ą	ទុ	٩	ą	ğ	>10(	ς g ∉ ⊋ g χ	decade	ens.	concer	G. 1 %

of tenths of a per less than 0.1% economic concer

Table 13-1 Typical concentrations of selected elements in rocks [mg/kg (ppm)] and in streams and the ocean [µg/kg (ppb)] (from Turekian 1971a; Martin and Meybeck 1979; and other sources).

	Granite	Basalt	Shale	Sandstone	Limestone	Streams	Осевя
Lithium	30	17	66	15	5	10	170
Beryllium	3	1	3				0.006
Boron	10	5	100	35	20	20	4450
Fluorine	800	400	740	270	330	100	1300
Alumoum	Major	Major	Major	Major	4200	50	1
Scandium	10	30	13	1	1	0.004	0.0004
Titanium	Major	Major	Major	Major	400	10	1
Vanadium	50 [°]	250	130	20	20	1	2
Chromium	10	170	90	35	11	1	0.2
Manganese	450	1500	850	50	1100		0.2
Iron	Major	Major	Major	Major	Major	40	2
Cobalt	4	44	19	0.3	0.1	0.2	0.05
Nickel	10	130	68	2	20	2	0.5
Copper	20	87	45	2	4	7	0.5
Zinc	. 50	105	95	16	20	30	. 2
Gallium	17	17	19	12	4	0.1	0.03
Germanium	1	1	2	1	0.2		0.06
Artenic	2	2	13	1	1	2	3

Scienzum	0.05	0.05	0.6	0.05	0.9	0.2	0.1
Bromine	4	4	4	1	6	20	67300
Rubidium	150	130	140	60	3	Ī	120
Strontum	250	465	300	20	600	60	\$100
Yttrium	40	25	35	10	4	0.07	0.001
Zirconium	150	140	160	220	20		0.03
Molybdenum	ı	1.5	2.6	0.2	0.4	0.5	10
Silver	0.04	0.1	0 07			0.3	0.04
Cadmium	0.13	0.2	0.3		0.03		0.05
Antimony	0.2	0.1	ı	0.4	0.3	1	0.3
lodine	0.5	0.5	2	1	1	7	64
Cessum	3	1	6	6	6	0.03	0.3
Banum	600	330	580	•	10	50	10
Rare earths	0.5-70	1-80	1-80	0.05-15	0.05-8	0.001-0 1	0.001
Tungsten	1.7	0.7	1.8	1.6	0.6	0.03	< 0.001
Gold	0.002	0.002	0.005	0.006	0.006	0 002	0.004
Mercury	0.03	0.01	0.4	0 03	0.04	0.07	0 03
Thallium	1.5	0.2	1.4	0 8	0.0.	G. G.	<0.01
Lead	17	6	20	7	9	1	0.03
Тьопит	14	2.7	12	5.5	2	0.1	< 0.0005
Uranium	3	1	4	2	2	0.1	3.3